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# USE OF THE WATER ELUTRIATOR IN ADDITION TO SCREEN TESTS IN DETERMINING FINENESS DISTRIBUTION OF MILLED ENAMEL*

By L. A. Lange and R. L. Fellows

Abstract

A method of using a water elutriator in combination with screen tests to determine the fineness distribution of milled enamels is described. Results of tests of milled enamels which were ground under various conditions are given.

## I. Introduction

The fineness of milled enamels has been usually designated as a certain percentage of residue on a given screen and some work has been done in the distribution of the residues of enamels retained on screens up to 325-mesh, but there has always been a question as to the fineness distribution beyond 325-mesh. This has been especially true in comparing enamels from different mills.

In order to study the fineness of milled enamels beyond a 325-mesh sieve, the problem of measuring the fineness presented itself. After considering several methods of separation, the water elutriator was tried because the milled enamel could be used without additional preparation. After preliminary trials with water elutriation, the apparatus described here was built.

The data that will be presented were obtained with the elutriator, and the results were combined with screen tests of the same enamels.

## II. Apparatus and Method

### (1) Description of Apparatus

Figure 1 is a photograph of the apparatus; *A* is tap-water inlet; *B* is a sand filter to remove any foreign material in the water (this was added to the apparatus after it was found that rust in the water was being collected in some of the cans); *C* is an overflow can to provide a constant water level; *D* is an orifice which may be varied in size to produce a desired rate of flow of water; *E* is loading can; *F*, can No. 1; *G*, can No. 2; *H*, can No. 3; *I*, can No. 4; *J*, can No. 5; *K*, can No. 6; and *L*, can No. 7. The loading can is about the same size as can No. 1. All of the cans, funnels, etc., are made of brass.

### (2) Development of Elutriation Procedure and Standardization of Apparatus

Attempts to charge the elutriator by means of a burette or similar apparatus were unsuccessful owing to the set of the enamel as it came from the mill, which, when thinned down, settled and clogged the burette orifice. The use of a "loading" can, similar in size to can No. 1, gave good results. The desired amount of enamel was placed in the loading can and, when the water was started, the enamel was slowly carried over to the following cans. It was necessary to stir the contents in this can from time to time to loosen the heavy enamel in the bottom. After several hours, only a small amount of residue remained, the water was shut off, the residue was transferred into can No. 1, and the elutriation was then continued.

The size of the orifice necessary to secure a desired rate of flow was determined by experiment and, with a constant head maintained by overflow can *C*, there was little trouble with variation in the rate of flow. It was found that 80 to 90% of the solid material in a sheet-iron enamel was retained in the system at a water flow of 250 cubic centimeters per minute, and this rate was adopted as standard for the tests in this paper. This rate of flow may be varied when comparing finer milled enamels or materials of different specific gravity.

Some variations in results were encountered in the first runs because the funnel tubes were not placed close enough to the bottom of the cans and some of the particles were trapped at the bottom of the cans. To overcome this, a spacer was made so that all of the tubes could be placed $^1/_{16}$ inch from the bottom of the cans. By placing them this close to the bottom, the flow of the water out of the funnel washed the enamel away from the bottom and up into the cans and more uniform results were obtained.

The rate of the flow of water along the sides of the cones in the cans was retarded, and some of the particles settled along the cones. To obtain uniform results, it was necessary to stir the contents of the cans at least once to get these particles in suspension again so that they could be carried over into the following cans. It was found that

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 24, 1937 (Enamel Division).

if the contents of the cans were stirred after the water in the cans had cleared up the first time and then were allowed to settle for about two hours before proceeding with the elutriation, the results were satisfactory. For finer enamels than were used in this test, it was necessary to stir the residues after the water had cleared a second time and then to run until the water cleared.

If the water flow is constant, the size of the grains settling in the cans varies with the upward velocity of the water in the cans, and this velocity is determined by the area of the can. The average grain size of the residue of each can as well as the material retained on the screens used in these tests was determined by means of microscopic grain counts.[1] The values for the particle size of

TABLE I

| Screen No. | Specified opening (microns) | Measured opening (microns) | Variation in particle size (microns) | Av. particle size (microns) |
|---|---|---|---|---|
| 150 | 104 | 112 | 145–290 | Above 145 |
| 200 | 74 | 75 | 72–145 | 110 |
| 270 | 53 | 65 | 74–120 | 80 |
| 325 | 43 | 40 | 46–74 | 65 |

the residues on the screens and in the cans are given for one of the enamels in this test. The average grain size of the residues on the 150-mesh screen and in the No. 1 can will vary somewhat from the values given because there is no screen ahead of them, but the other values are fairly representative of all of the enamels tested. The grain size of other material than the ground coat used, of course, will vary with the specific gravity of the particles. The actual size of the openings of the screens used in these tests was also measured with the microscope.

[1] G. St. J. Perrott and S. P. Kinney, "The Meaning and Microscopic Measurement of Average Particle Size," *Jour. Amer. Ceram. Soc.*, **6** [2] 417–39 (1923).

Table I gives the mesh, size of opening, and average grain size of the residues of the enamel on the sieves used in the tests. Table II gives the dimensions, velocity of water, and average grain size of the residues for the cans.

### (3) Method of Making Fineness Tests

In determining the fineness on 150-, 200-, 270-, and 325-mesh screens, a sample of wet-milled enamel to give 100 grams of dry material was weighed and carefully washed through the four nested sieves. After drying the material in the screens, the nest of screens was shaken for 15 minutes on a Ro-Tap shaker. The residues on the screens were weighed and reported. One hundred grams of dry material were taken as standard rather than 100 grams of frit (as specified in standard method of the Enamel Division of the American Ceramic Society) because, in these tests, the fineness distribution of the total enamel was determined rather than just a small percentage of frit. The values for the ground-coat enamel in these tests may be changed to the American Ceramic Society method by multiplying by a factor of 1.11.

In determining the fineness distribution by the elutriator, a new sample of the enamel of the same amount as used in the screen test was placed in the loading can of the elutriator. All of the settling cans were filled with water, and the water was started slowly into the loading can. At first the clay and frit particles were carried over into the following cans and, as the water flow was increased, more and more enamel was carried into the following cans. The enamel in the loading can was stirred at intervals to aid it in being carried over. The water flow was increased to 250 cubic centimeters per minute and was kept constant by keeping the water overflowing in the constant head can. As elutriation progressed,

TABLE II

(Rate of flow 250 cc./min.)

| Can No. | Diam. (cm.) | Area (cm.²) | Area of tube (cm.²) | Net area (cm.²) | Upward velocity of water (mm./min.) | Variations in particle size (microns) | Av. particle size (microns) |
|---|---|---|---|---|---|---|---|
| 1 | 4.90 | 18.84 | 0.97 | 17.87 | 139.8 | 72.4–over | Above 72.4 |
| 2 | 6.60 | 34.21 | " | 33.24 | 75.3 | 37.0–74 | 58.0 |
| 3 | 8.70 | 59.40 | " | 58.43 | 42.8 | 37.0–65 | 45.0 |
| 4 | 11.20 | 98.50 | " | 97.53 | 25.6 | 18.5–55 | 34.0 |
| 5 | 13.20 | 136.80 | " | 135.83 | 18.4 | 9.0–46 | 30.0 |
| 6 | 20.20 | 320.00 | " | 319.00 | 7.8 | 4.0–37 | 18.5 |
| 7 | 35.70 | 1000.00 | " | 999.00 | 2.5 | 1.5–23 | 11.3 |
| No. 2 can after removing material on 325-mesh sieve. | | | | | | | 55.0 |

all but a small amount was carried over from the loading can. The coarse particles settled in the the No. 1 can, the next coarse in the No. 2 can, and the finer particles in the larger cans. After a

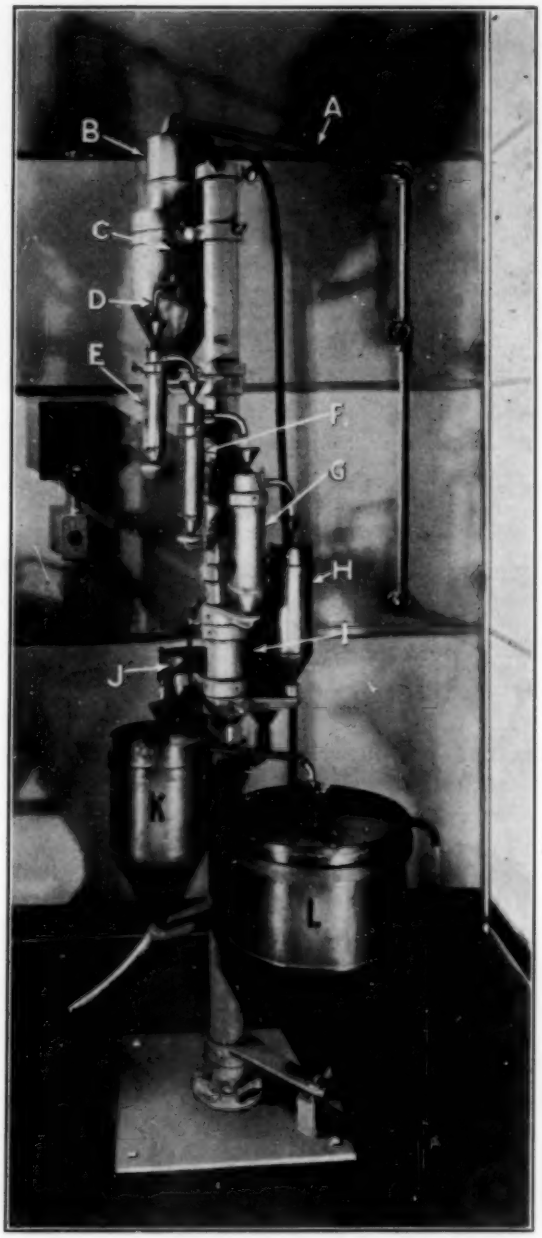


FIG. 1.

few hours, the water and the remaining enamel was poured slowly from the loading can and was washed into the No. 1 can. The loading can was replaced, and elutriation was continued with the water flowing at 250 cubic centimeters per minute for 24 hours or until the water in the last can had cleared up. Some of the enamel settled on the sides of the cones of the cans in the first 24 hours; about two inches of water were siphoned from each can and the residue was stirred from the bottom of all of the cans. After allowing the water to settle for two hours, the flow was started again at 250 cubic centimeters per minute and the elutriation continued until the water in the last can cleared up. The residues were removed from the cans, dried, and weighed.

## III. Comparison of Fineness Distribution of Enamels

### (1) Variation in Fineness on 200-Mesh

Screen and elutriation tests were made on enamels which were milled to various degrees of fineness as measured on a 200-mesh screen. The enamel was prepared by milling one hundred pounds of ground-coat frit in a mill, 31 by 19 inches inside diameter, which revolved at 35 r.p.m. The pebble charge was approximately 84 pounds of 3-inch pebbles, 20 pounds of 2-inch pebbles, and 80 pounds of $1^1/_2$-inch pebbles. The mill formula used was as follows:

| | (lb.) |
|---|---|
| Frit A | 75 |
| Frit B | 25 |
| Clay | 7 |
| Feldspar | 3 |
| Borax | $^3/_4$ |
| Water | 50 |

Six 1-quart samples of the enamel were removed from the mill from time to time as the milling progressed.

Two elutriation tests and two screen tests were made on each sample, and the averages were taken. The results are shown in Table III. The data show that the majority of the residue from the No. 1 can would be held on a 270-mesh screen and all of it would be retained on a 325-mesh screen. About one-half of the residue from the No. 2 can is retained on a 325-mesh screen, and the No. 2 325-mesh separation is obtained by subtracting the total cumulative percentage on the 325-mesh screen, as determined by the screen test from the cumulative percentage residue of the No. 1 and No. 2 cans in the elutriator test. By this method, the elutriation and screen tests are combined to give a distribution of fineness of the enamels from 150-mesh down to the particles of colloidal size.

Figure 2 shows the cumulative percentage of the residues plotted against the average particle

size. The curves for the coarser milled enamels have a gradual curve from the coarser grains to zero, while the curves for the finer milled enamels have a gradual slope up to a certain point; then

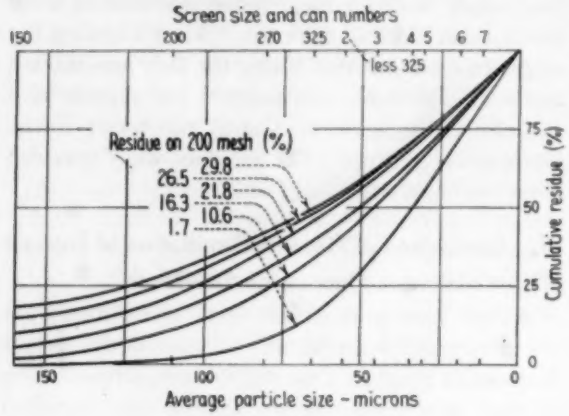


FIG. 2.

the curve suddenly becomes steeper and approaches a straight line toward zero grain size at 100% residue.

### (2) Variation in Amount of Mill Charge

In order to study the effect of undercharging and overcharging the mill on the fineness distribution of the enamel, screen and elutriation tests

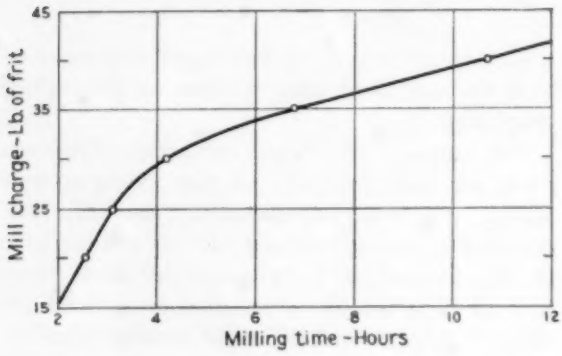


FIG. 3.

were made of enamels milled with variable amounts of frit charges.

The enamels were milled under laboratory controlled conditions in a mill, $18^1/_2$ by 13 inches inside diameter. The mill contained 30 pounds of 2-inch pebbles and 40 pounds of $1^1/_2$-inch pebbles. The mill turned at 57.5 r.p.m.

The weights of frit charges which were milled, keeping the remainder of the mill additions in proportion, were 40, 35, 30, 25, and 20 pounds.

Each mill was run approximately to 13% on 200-mesh from a 100-gram sample of dry material. The mill time was plotted against mill charge in Fig. 3.

Two screen and elutriation tests were made and averaged, and the results are shown in Table IV. Figure 4 shows the curves for the 20- and 40-

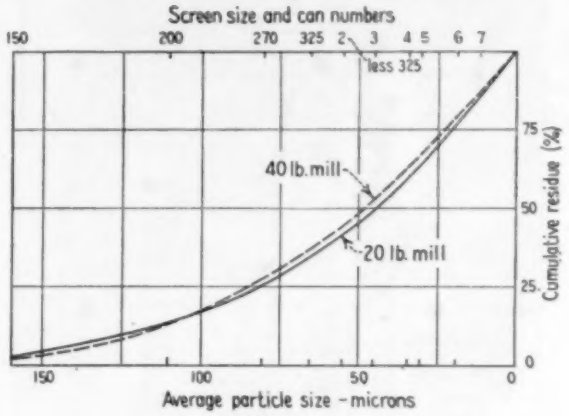


FIG. 4.

pound mills, which are the extremes in the mill charges as well as in the results. The curves for the other enamels fall in between these curves.

### (3) Variation in Water Content Used in Milling

The water content used in milling was varied in order to find its effect on the fineness distribution of milled enamel.

The enamels were milled in the same size mill as in other tests with 30 pounds of frit, the water

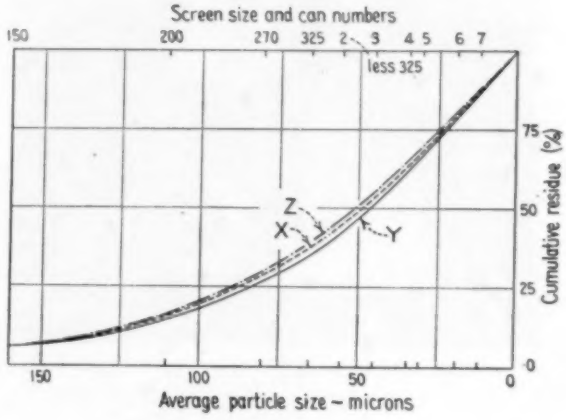


FIG. 5.

content varying from 35 to 40, 50, 60, and 70%. The water was added to the mills after they had been washed and allowed to drain for 10 minutes.

TABLE III

| | Screen or can No. | Av. particle size (microns) | Enamel A | | | | Enamel B | | | | Enamel C | | | | Enamel D | | | | Enamel E | | | | Enamel F | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative |
| Screen test | 150 | 145 | 12.4 | 12.8 | 12.6 | 12.6 | 9.9 | 10.2 | 10.1 | 10.1 | 6.9 | 7.1 | 7.0 | 7.0 | 4.3 | 4.5 | 4.4 | 4.4 | 2.0 | 2.2 | 2.1 | 2.1 | 0.1 | 0.1 | 0.1 | 0.1 |
| | 200 | 110 | 16.8 | 17.5 | 17.2 | *29.8* | 16.1 | 16.8 | 16.4 | *26.5* | 14.5 | 15.1 | 14.8 | *21.8* | 11.5 | 12.2 | 11.9 | *16.3* | 8.1 | 8.8 | 8.5 | *10.6* | 1.5 | 1.6 | 1.6 | *1.7* |
| | 270 | 80 | 13.8 | 13.9 | 13.8 | 43.6 | 14.3 | 14.2 | 14.3 | 40.8 | 14.6 | 15.2 | 14.9 | 36.7 | 14.2 | 14.3 | 14.2 | 30.5 | 13.2 | 14.1 | 13.6 | 24.2 | 5.4 | 5.6 | 5.5 | 7.2 |
| | 325 | 65 | 8.2 | 7.5 | 7.9 | 51.5 | 8.6 | 8.5 | 8.6 | 49.4 | 9.6 | 8.8 | 9.2 | 45.9 | 9.4 | 9.7 | 9.6 | 40.1 | 10.4 | 9.4 | 9.9 | 34.1 | 7.7 | 8.3 | 8.0 | 15.2 |
| Elutriation test | 1 | 73.0 | 44.0 | 43.9 | 44.0 | | 41.9 | 43.6 | 42.8 | | 38.7 | 38.2 | 38.5 | | 31.1 | 32.2 | 31.7 | | 26.1 | 25.9 | 26.0 | | 9.2 | 8.9 | 9.1 | |
| | 2 | 58.0 | 11.6 | 11.7 | 11.6 | | 13.0 | 10.6 | 11.8 | | 13.4 | 14.1 | 13.7 | | 14.8 | 14.2 | 14.5 | | 15.1 | 15.5 | 15.3 | | 14.3 | 14.7 | 14.5 | |
| | 2–325 | 55.0 | 4.4 | 3.8 | 4.1 | 55.6 | 6.0 | 4.5 | 5.2 | 54.6 | 6.5 | 6.1 | 6.3 | 52.2 | 6.5 | 5.7 | 6.1 | 46.2 | 7.5 | 6.9 | 7.2 | 41.3 | 8.8 | 8.0 | 8.4 | 23.6 |
| | 3 | 45.0 | 8.2 | 3.5 | 5.9 | 61.5 | 9.6 | 9.3 | 9.4 | 64.0 | 8.2 | 7.2 | 7.7 | 59.9 | 9.8 | 10.3 | 10.1 | 56.3 | 6.8 | 11.3 | 9.1 | 50.4 | 15.5 | 15.4 | 15.5 | 39.1 |
| | 4 | 34.0 | 7.0 | 11.4 | 9.2 | 70.7 | 6.1 | 5.9 | 6.0 | 70.0 | 8.4 | 9.6 | 9.0 | 68.9 | 7.7 | 7.4 | 7.5 | 63.8 | 14.0 | 9.1 | 11.5 | 61.9 | 11.3 | 10.7 | 11.0 | 50.1 |
| | 5 | 30.0 | 4.2 | 4.8 | 4.5 | 75.2 | 4.4 | 4.0 | 4.2 | 74.2 | 4.9 | 4.0 | 4.5 | 73.4 | 4.5 | 4.9 | 4.7 | 68.5 | 5.3 | 5.9 | 5.6 | 67.5 | 6.6 | 6.5 | 6.5 | 56.6 |
| | 6 | 18.5 | 10.1 | 9.0 | 9.5 | 84.7 | 10.6 | 10.8 | 10.7 | 84.9 | 10.2 | 10.9 | 10.5 | 83.9 | 12.1 | 10.6 | 11.4 | 79.9 | 12.4 | 11.7 | 12.1 | 79.6 | 13.9 | 12.5 | 13.2 | 69.8 |
| | 7 | 11.3 | 3.8 | 3.5 | 3.7 | 88.4 | 4.2 | 4.0 | 4.1 | 89.0 | 4.2 | 5.1 | 4.7 | 88.6 | 5.5 | 4.5 | 4.9 | 84.8 | 6.6 | 7.1 | 6.8 | 86.4 | 9.7 | 12.1 | 10.9 | 80.7 |
| | Through | 1.5 | 11.1 | 12.2 | 11.6 | 100.0 | 10.2 | 11.8 | 11.0 | 100.0 | 12.0 | 10.9 | 11.4 | 100.0 | 14.5 | 15.9 | 15.2 | 100.0 | 13.7 | 13.5 | 13.6 | 100.0 | 19.5 | 19.2 | 19.3 | 100.0 |

TABLE IV

| | Screen or can No. | Av. particle size (microns) | 20-lb. mill | | | | 25-lb. mill | | | | 30-lb. mill | | | | 35-lb. mill | | | | 40-lb. mill | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative | Test 1 | Test 2 | Av. | Cumulative |
| Screen test | 150 | 145 | 3.9 | 4.3 | 4.1 | 4.1 | 3.9 | 4.2 | 4.1 | 4.1 | 3.4 | 3.7 | 3.6 | 3.6 | 3.0 | 3.2 | 3.1 | 3.1 | 3.0 | 3.2 | 3.1 | 3.1 |
| | 200 | 110 | 9.2 | 10.0 | 9.6 | *13.7* | 9.7 | 10.4 | 10.0 | *14.1* | 10.0 | 10.7 | 10.3 | *13.9* | 9.8 | 10.1 | 10.0 | *13.1* | 10.2 | 10.6 | 10.4 | *13.5* |
| | 270 | 80 | 12.0 | 12.6 | 12.3 | 26.0 | 12.4 | 12.8 | 12.6 | 26.7 | 12.7 | 13.6 | 13.2 | 27.1 | 13.3 | 14.7 | 14.0 | 27.1 | 13.5 | 14.8 | 14.2 | 27.7 |
| | 325 | 65 | 10.4 | 8.7 | 9.6 | 35.6 | 9.5 | 9.1 | 9.3 | 36.0 | 10.3 | 8.4 | 9.3 | 36.4 | 9.9 | 9.3 | 9.6 | 36.7 | 9.8 | 9.0 | 9.4 | 37.1 |
| Elutriation test | 1 | 73.0 | 26.8 | 28.4 | 27.6 | | 27.9 | 29.1 | 28.5 | | 29.7 | 30.3 | 30.0 | | 29.3 | 28.8 | 29.1 | | 28.3 | 29.8 | 29.1 | |
| | 2 | 58.0 | 13.8 | 13.0 | 13.4 | | 14.4 | 14.2 | 14.3 | | 14.2 | 15.1 | 14.7 | | 14.9 | 13.8 | 14.3 | | 14.7 | 15.2 | 14.9 | |
| | 2–325 | 55.0 | 5.1 | 5.8 | 5.4 | 41.0 | 6.8 | 6.8 | 6.8 | 42.8 | 7.5 | 9.0 | 8.3 | 44.7 | 8.2 | 5.3 | 6.7 | 43.4 | 6.5 | 7.4 | 6.9 | 44.0 |
| | 3 | 45.0 | 9.3 | 6.9 | 8.1 | 49.1 | 5.9 | 10.9 | 8.4 | 51.2 | 9.0 | 6.3 | 7.6 | 52.3 | 11.3 | 11.1 | 11.2 | 54.6 | 10.6 | 6.4 | 8.5 | 52.5 |
| | 4 | 34.0 | 9.0 | 12.6 | 10.8 | 59.9 | 13.5 | 10.8 | 12.2 | 63.4 | 10.6 | 14.2 | 12.4 | 64.7 | 10.4 | 9.9 | 10.2 | 64.8 | 8.2 | 14.6 | 11.4 | 63.9 |
| | 5 | 30.0 | 4.7 | 4.8 | 4.7 | 64.6 | 4.1 | 6.4 | 5.2 | 68.6 | 4.7 | 8.3 | 6.5 | 71.2 | 5.2 | 4.5 | 4.8 | 69.6 | 4.3 | 4.1 | 4.2 | 68.1 |
| | 6 | 18.5 | 12.0 | 12.5 | 12.3 | 76.9 | 10.2 | 8.0 | 9.1 | 77.7 | 8.9 | 7.2 | 8.1 | 79.3 | 10.1 | 12.4 | 11.3 | 80.9 | 11.7 | 10.6 | 11.2 | 79.3 |
| | 7 | 11.3 | 7.2 | 6.5 | 6.8 | 83.7 | 7.4 | 6.6 | 7.0 | 84.7 | 7.5 | 4.6 | 6.0 | 85.3 | 3.9 | 4.8 | 4.3 | 85.2 | 7.2 | 5.9 | 6.5 | 85.8 |
| | Through | 1.5 | 17.2 | 15.3 | 16.3 | 100.0 | 16.6 | 14.0 | 15.3 | 100.0 | 15.4 | 14.0 | 14.7 | 100.0 | 14.9 | 14.7 | 14.8 | 100.0 | 15.0 | 13.4 | 14.2 | 100.0 |

The enamel milled with 35% water was very thick and would not run from the mill; the mill containing 50% water was about of average consistency of the milled ground coats; the mill containing 70% water was much thinner than could be used.

Screen and elutriation tests were made as before on mills with 35, 50, and 70% water content only, because there was little difference in the results of the three enamels.

### (4) Commercial Grinds

Screen and elutriation tests of several commercial batches of milled enamels were determined as before from wet samples of milled enamels equivalent to 100 grams of dry material in order to compare the results with experimental mills. The results are given in Table V. Figure 5 shows curves for these enamels.

TABLE V

| Screen or can No. | Av. particles size (microns) | Commercial grinds No. X Av. | No. X Cumulative | No. Y Av. | No. Y Cumulative | No. Z Av. | No. Z Cumulative |
|---|---|---|---|---|---|---|---|
| 150 | 145 | 4.8 | 4.8 | 4.8 | 4.8 | 5.2 | 5.2 |
| 200 | 110 | 10.9 | *15.7* | 9.9 | *14.7* | 11.1 | *16.3* |
| 270 | 80 | 12.8 | 28.5 | 12.2 | 26.9 | 13.2 | 29.5 |
| 325 | 65 | 8.4 | 36.9 | 8.0 | 34.9 | 9.8 | 39.3 |
| 1 | 73.0 | (31.6) | | (28.5) | | (32.5) | |
| 2 | 58.0 | (12.9) | | (13.2) | | (13.8) | |
| 2-325 | 55.0 | 7.6 | 44.5 | 6.8 | 41.7 | 7.0 | 46.3 |
| 3 | 45.0 | 8.2 | 52.7 | 10.5 | 52.2 | 7.0 | 53.3 |
| 4 | 34.0 | 11.0 | 63.7 | 9.7 | 61.9 | 12.7 | 66.0 |
| 5 | 30.0 | 5.3 | 69.0 | 9.2 | 71.1 | 4.1 | 70.1 |
| 6 | 18.5 | 9.6 | 78.6 | 9.3 | 80.4 | 12.1 | 82.2 |
| 7 | 11.3 | 7.0 | 85.6 | 4.7 | 85.1 | 4.8 | 87.0 |
| Through | 1.5 | 14.4 | 100.0 | 14.9 | 100.0 | 13.0 | 100.0 |

## IV. Discussion

### (1) Variation in Fineness on 200-Mesh Sieve

The results show that the measurement of fineness of milled enamels by the residue retained on a 200-mesh screen should give a good comparative measure of the fineness of milled enamels as a whole within the range of commercial use.

From the results of these tests, it appears that sufficient data could be obtained through the use of five or six screens from 100-mesh to about 400-mesh to draw the curves for milled enamels of the usual fineness, inasmuch as the characteristics of the curves beyond the 200-mesh screen have been determined and the curves should end at zero particle size at 100% cumulative per cent residue.

### (2) Variation in Amounts of Mill Charge

From the data it appears that, in the range of mill charges tested, there is little difference in the fineness distribution from varying the mill charge when the enamels are milled to the same fineness as measured on a 200-mesh screen. The results indicate that the enamel from the 20-pound mill is, as a whole, a little coarser than the enamel from the 40-pound mill, although the screen test on the 200-mesh sieve is practically the same.

### (3) Variation in Water Content

The results show that the fineness distribution of the three enamels are similar and that apparently there is no variation in the fineness distribution by varying the water content in milling when the enamels are milled to the same fineness on a 200-mesh sieve.

### (4) Commercial Grinds

The percentage cumulative residue *vs.* average particle-size curves show that commercial grinds of enamels have the same characteristics as the enamels milled in laboratory mills.

## V. Conclusions

The water elutriator may be used in conjunction with screen tests to determine the fineness distribution of enamels. It is slow, however, and is better suited to research work rather than for control purposes.

The measurement of the fineness of milled enamels by the percentage residue on the 200-mesh sieve as used for mill-room control is a satisfactory measure of the fineness of enamel.

Most of the variation in the milling of enamels is apparently in the coarser range of particle size, and the difference in most cases could probably be determined with a careful screen analysis using several screens from 100-mesh down to 325-mesh or finer.

Varying the amount of mill charge has little effect on the fineness distribution of the enamels tested, although undercharging a mill seems to tend toward a coarser enamel when the enamels are milled to the same fineness on a 200-mesh sieve.

No difference in the fineness distribution could be noticed because of varying the water content of the mill charge.

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# RANDOM EXPERIMENTS ON ENAMEL ADHERENCE*

BY KARL KAUTZ

ABSTRACT

The results of various experiments dealing with the behavior of ground-coat enamels are given. Hydrogen causes metallic nickel or iron to separate from regular molten ground coats, while the gases evolved from sheet iron cause metallic copper to form from molten copper-bearing glasses and metallic iron to form from regular molten ground coats. Ground coats have only a slight volatilization loss at 1600°F. Because CuO decomposes when heated in absence of oxygen or with iron or FeO, the various experiments performed suggest that glass solutions of CuO are oxidizing and are reduced by such reducing agents as $H_2$, CO, FeO, CoO, NiO, MnO, and Fe.

## I. Introduction

In recent discussions[1] of papers on the adherence of sheet-steel ground coats, a number of experiments were cited by the writer which had not been published. This paper deals principally with those experiments so that they may be recorded in the form of original articles.

## II. Tests on Metallic Particles Produced by Gases

### (1) Glasses Containing Cupric Oxide Fired on Iron

A glass containing 98% melted borax and 2% cupric oxide was smelted and ground dry. Another glass containing 98% melted boric acid and 2% cupric oxide was likewise prepared. These glasses were screened onto cleaned and pickled enameling iron samples and fired at 1450°F for five minutes. After firing, the glasses were removed by flexing the metal. The glass came off in large pieces. The contact side of the glass showed metallic copper or red cuprous oxide imbedded in the glass in both cases. The gas cavities or bubbles at the glass surface contact were more brilliantly coated than were places where smooth contact occurred. Gas bubbles trapped in the layer of $B_2O_3$ glass (owing to its higher viscosity) were larger and were brilliantly lined with cuprous oxide. When layers of $B_2O_3$ glass thicker than $^1/_8$ inch were fired on iron, removed, and broken so that the bubbles in the body of the glass were sectioned, their interiors were brilliantly coated with red cuprous oxide.

This experiment shows that cupric oxide dissolved in glasses can easily be reduced to metallic copper or red cuprous oxide by the gases which are evolved from commercial sheet iron when heated in air.

### (2) Reduction of Ground-Coat Enamels Heated in Hydrogen

A porcelain boat was filled with freshly milled commercial ground-coat enamel, dried, heated at 1600°F in an electric combustion tube furnace for 30 minutes in a current of dry hydrogen, and cooled for about 30 minutes in the same atmosphere. Another porcelain boat, filled with the same ground coat, which had previously been fired on iron to the normal stage, then removed by bending and flexing the sample, and finely ground, was heated alongside the first and given identical treatment.

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* Received September 17, 1937.

[1] (*a*) Karl Kautz, "Discussion on Lord's Paper," *Jour. Amer. Ceram. Soc.*, **20** [4] 115–20 (1937).

(*b*) Karl Kautz, "Reply to Staley's Discussion on 'A Critical Analysis of Some Statements and Experiments on the Adherence of Sheet-Steel Ground Coats,'" this issue, p. 311.

With the freshly milled, pure ground-coat enamel, numerous flakes or spangles of bright metal had formed on the surface of the glass. Some of these, more than 1/4 inch in diameter, were carefully stripped from the glass. Chemical analysis showed iron 6.78%, nickel 91.11%, and a trace of cobalt.

FIG. 1.—Globules of nickel reduced from ground-coat enamel by hydrogen at 1600°F; unetched, × 500. (The white circles represent spheres of metallic nickel sectioned during the polishing of the specimen. The dark background represents ground-coat glass.)

A microsection through the glass is shown in Fig. 1.

The glass, especially near the top surface, had numerous globules or spherical particles of metal, presumably nickel, imbedded in it. These globules ranged in size from those shown to some ten times this size. The balls or globules (nickel?) were characteristic, and no other shape could be found.

The fired ground-coat glass, which had been removed from iron samples and which undoubtedly contained considerable dissolved ferrous oxide, had been severely reduced. A scum or crust of reduced metal, more than one-half the thickness of the melt, had formed over the glass. Although the removed fired enamel probably contained a small amount of metallic iron particles removed with the glass, the metallic content was immensely increased after this treatment. Chemical analysis showed this metallic crust to consist of iron 92.83%, nickel 4.54%, and a trace of cobalt.

A microsection through the underlying glass is shown in Fig. 2.

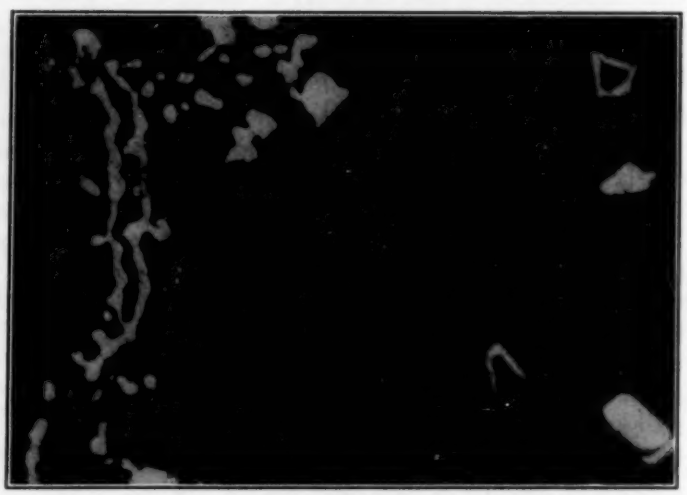

FIG. 2.—Particles of iron reduced from ground-coat enamel rich in ferrous oxide by hydrogen at 1600°F; unetched, × 500.

Metallic globules, presumably nickel, were occasionally observed but are not shown in Fig. 2. The small reduced iron particles have the appearance of oblate globules which later probably coalesce into large irregular shapes and stringers. Sometimes the reduced iron particles exhibit almost perfect crystallographic outlines, in spite of the rapid cooling.

This experiment illustrates the ease with which glass solutions of iron and nickel oxides are reduced by strong reducing gases at enameling temperatures. Hydrogen and carbon monoxide at high temperatures are the strongest reducing gases known. What took place in this experiment with hydrogen probably could be duplicated with carbon monoxide. It was shown by Lucian and Kautz[2] that carbon monoxide is persistently evolved when enameling iron is heated, and it seems probable that, under certain conditions, carbon monoxide evolved from the base iron may act to cause reduction of the

[2] A. N. Lucian and Karl Kautz, "Study of Gases in Enameling Iron," *Jour. Amer. Ceram. Soc.*, **17** [6] 167–72 (1934).

dissolved iron and nickel oxides in ground-coat glasses.

### (3) Reduction of Ground-Coat Enamels by Gases Evolved from Commercial Iron

Freshly milled, commercial ground-coat slip was cast in the form of a disk on a cleaned and pickled iron surface. After drying, this disk was approximately 3 inches in diameter and about $^3/_8$ inch thick. A solution of sodium silicate (water glass) was applied to the surface of this dried mass to prevent the easy escape of evolved gases during firing. After drying again, the sample was fired at 1600°F for six minutes.

The glass bloated approximately to double its original thickness and became quite vesicular from the evolved gases. Some bubbles were nearly $^1/_2$ inch in diameter and ranged down to microscopic size. The lower half of the large bubbles near the interface, that is, in the dissolved ferrous-oxide layer, were brilliantly coated on their interiors with a silvery metal, which undoubtedly was preponderantly iron.

This experiment illustrates the ease with which dissolved ferrous oxide, and possibly nickel oxide, may be reduced from commercial ground-coat enamels by gases evolved from commercial iron during heating in air.

## III. Volatilization of Ground-Coat Frits

The stability of ground-coat glasses at enameling temperatures has often been questioned. Some investigators believe that ground coats are quite volatile or are capable of being burned or oxidized. When a substance is burned or oxidized, there usually is either (1) a large increase in weight if the products of oxidation are solids or (2) a large decrease in weight if the products of oxidation can escape as gases. A simple loss in weight determination will therefore determine the degree of stability of ground-coat glasses at enameling temperatures.

### (1) Loss in Weight of Ground-Coat Frits at 1600°F

A soft member of a commercial twin ground coat, after thoroughly drying at 250°F, was carefully weighed into four porcelain crucibles. These open crucibles were heated at 1600°F in an enameling furnace for 5, 10, 30, and 60 minutes, respectively, cooled in a desiccator, and weighed. The results were as follows:

| Total time heated (min.) | Total loss in weight (%) |
|---|---|
| 5 | 0.004 |
| 10 | 0.02 |
| 30 | 0.04 |
| 60 | 0.05 |

These results show that the loss in weight of commercial ground-coat frits is practically negligible at 1600°F. Since commercial ground-coat frits usually contain fluorine, a slight volatilization loss might be expected to occur, owing to the escape of such volatile compounds as $BF_3$ or $SiF_4$. Some compounds of sodium may also volatilize at these temperatures. This loss in weight is so slight that it is improbable that oxidation played a part in the loss. The term "burned up" applied to fired ground-coat enamels is misleading; what actually burns or oxidizes is the surface of the iron underneath the glass layer. The molten glass layer actually increases in weight owing to absorption of iron oxides formed by this oxidation.

## IV. Reduction of Glasses Containing Cupric Oxide

### (1) Reduction of Cupric Oxide by Metallic Iron and Ferrous Oxide

Cupric oxide (CuO) was thoroughly mixed and ground with finely divided sponge iron and heated in a sealed porcelain crucible at 1400°F for 15 minutes. When cold, the contents of the crucible showed considerable cuprous oxide and metallic copper. This experiment was repeated with ferrous oxide instead of finely divided sponge iron with almost identical results.

This experiment leads to the conclusion that cupric oxide at high temperatures is a strong oxidizing agent because it readily oxidizes metallic iron or ferrous oxide according to the reactions

$$CuO + Fe \rightarrow FeO + Cu$$
$$2CuO + Fe \rightarrow FeO + Cu_2O$$
$$CuO + 3FeO \rightarrow Fe_3O_4 + Cu$$
$$2CuO + 3FeO \rightarrow Fe_3O_4 + Cu_2O$$

### (2) Reduction of Cupric Oxide Dissolved in Glasses by Various Monoxides

Oxides purchased from commercial supply houses are often of variable composition. To overcome this difficulty, carefully prepared quantities of the monoxides of iron, manganese, nickel, and cobalt were made.

(*a*) *Ferrous Oxide:* This oxide has never been prepared pure, although chemical literature is

full of various attempts to prepare it. One of the most convenient methods the writer has found for the preparation of FeO is by oxidizing metallic iron in steam at 1300° to 1400°F. By this method, a scale is formed which is very rich in FeO; it also contains small quantities of $Fe_3O_4$ and Fe.

(*b*) *Manganous Oxide:* This oxide was prepared by heating $MnCO_3$ in hydrogen at 1100°F.

(*c*) *Nickelous Oxide:* This oxide was prepared by heating $NiCO_3$ in a covered crucible in air at 1050°F.

(*d*) *Cobaltous Oxide:* This oxide was prepared by heating $Co_3O_4$ in hydrogen at 575° F.

These prepared oxides were packed in the bottom of porcelain crucibles and finely ground glass (containing 98% melted borax and 2% cupric oxide) was placed carefully over them, almost filling the crucible. A fragment of ammonium carbonate was placed on top of the glass to displace residual air during the early stages of heating. After sealing on the covers with sodium silicate, the crucibles were heated at 1500°F for 5 minutes. When cold, the crucibles were broken, and the line of contact was examined. It was found that cuprous oxide, flakes of metallic copper, or both, had formed at the contact between the molten copper-bearing glass and the oxide layer in all cases.

These experiments were repeated with commercial manganese dioxide ($MnO_2$), ferric oxide ($Fe_2O_3$), and nickel dioxide ($NiO_2$) substituted under the copper-bearing glass. No reduction could be found in any of these cases.

These experiments suggest that glass solutions of cupric oxide are oxidizing just as is free cupric oxide. The reductions could not possibly have taken place by electrochemical displacement because no free metals were involved. The fact that the monoxides of iron, manganese, nickel, and cobalt reduce glass solutions of cupric oxide, while the higher oxides of iron, manganese, and nickel do not, indicates oxidation-reduction reactions taking place at the glass contact.

### (3) Reduction of Cupric Oxide Dissolved in Glasses by Metallic Iron

Small pieces of 20-gage sheet iron, about 1/4 inch square, were placed in the bottom of a porcelain crucible and finely ground glass (containing 98% melted borax and 2% cupric oxide) was placed over them almost filling the crucible. After sealing on the cover, the crucible was heated at 1500°F for 5 minutes. When cold, the crucible was broken and the glass examined. It was found that the iron pieces had floated to the top of the melt and were partially oxidized on the exposed surfaces. The underneath side of the iron pieces had large bubbles under them. These bubbles were brilliantly coated on their interiors with metallic copper. The exposed surface of the iron where oxidation took place showed a mixture of iron oxide and red cuprous oxide. On the edges of the pieces, a slight coat of copper could be seen. This experiment was repeated with electrolytic iron of high purity which had been vacuum-melted. It was hoped that this would overcome the evolution of reducing gases from the metal base. The results, however, were practically the same as with commercial sheet iron. The amount of reduction in these experiments was estimated to be due to reducing gases 70 to 80%, ferrous oxide 20 to 30%, and metallic iron 0 to 10%.

The amount of gases evolved from iron when heated must be considerable. Here iron (with a specific gravity of 7.85) floated to the top of molten glass (with a specific gravity of about 2.35) by the buoyant effect of escaping gases. It was difficult to determine how much of the reduction of the cupric oxide dissolved in the borax glass was due to metallic iron alone. If metallic iron acted in this case, and it probably did, it could account only for a small portion of the reduction.

## V. Summary

Indications from the results of these various experiments may briefly be summarized as follows:

(1) The gases evolved from commercial sheet iron when heated are of such reducing nature and quantity as to cause red cuprous oxide, metallic copper, or both, to form from glasses containing cupric oxide.

(2) Hydrogen at enameling temperatures will cause metallic nickel to separate from commercial ground-coat enamels. If the enamel contains iron oxides, metallic iron is also formed, probably preferentially to nickel.

(3) The gases evolved from commercial sheet iron when heated are of such quantity and reducing nature as to cause metallic iron (and probably metallic nickel) to be reduced from

thick layers of commercial ground-coat enamels fired on iron.

(4) Commercial ground-coat enamel frits are remarkably stable at customary enameling temperatures. The almost negligible loss in weight is probably due to volatilization of some compound from the molten glass.

(5) Cupric oxide (CuO), when heated, acts very much like barium peroxide in being able to evolve oxygen. The reaction,

$$4CuO \rightleftarrows 2Cu_2O + O_2,$$

is reversible and depends upon the temperature and the partial pressure of oxygen. If oxygen is absorbed or removed, cupric oxide decomposes completely at high temperatures. Metallic iron or ferrous oxide will cause reduction of cupric oxide.

(6) Cupric oxide dissolved in glass is oxidizing, just as is free cupric oxide. This is shown by the fact that the monoxides of iron, manganese, nickel, and cobalt reduced cupric oxide in glass solution to red cuprous oxide or metallic copper. The higher oxides of iron, manganese, and nickel cause no reduction.

(7) Cupric oxide dissolved in glass is probably reduced by metallic iron by oxidation-reduction reactions. The evidence for reduction by metallic iron was not very conclusive in the foregoing experiments, being largely obscured by the greater reduction caused by ferrous oxide and reducing gases evolved from the iron base.

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# CHEMICAL DETERMINATION OF METALLIC PARTICLES AND OXIDES OF IRON, NICKEL, AND COBALT IN FIRED GROUND COATS*

BY KARL KAUTZ

ABSTRACT

Chemical methods were investigated and are described for studying the products formed in fired ground-coat enamels. The results obtained show that (1) the metallic particles are essentially iron with a trace of nickel, (2) a film of free FeO exists between glass and iron, (3) total FeO content increases with firing time, but the NiO and CoO content remains constant, and (4) no metallic cobalt and only a trace of metallic nickel is present on the iron surface on which ground coats have been fired and then removed.

## I. Introduction

The use of microscopic and X-ray methods[1] in studying ground-coat enamels has become well known in recent years, but little use has been made of reliable chemical methods. This paper deals with analytical chemical methods as a means of studying the products formed in fired ground coats.

These determinations may be divided into four parts as follows: (1) the composition and quantity of metallic particles found in the removed fired layers of ground-coat enamels, (2) the amount of free ferrous oxide adhering to the removed glass particles, (3) the total iron, nickel, and cobalt oxides in the removed glass particles, and (4) the metallic nickel and cobalt content on the iron surface after removing the fired ground-coat enamel.

## II. Preparation of Samples

Adjacently sheared samples of 20-gage enameling iron were thoroughly cleaned in a boiling commercial cleaner compound, rinsed, deeply pickled in sulfuric acid (7% $H_2SO_4$, 160°F, 35 minutes), rinsed, and neutralized. Commercial cobalt ground-coat enamel was applied at 36 grams per square foot (dry weight) and dried. The samples were then fired 2, 6, 20, and 60 minutes at 1600°F. The ground-coat enamel on the 2-minute series of samples had just become molten or glossy; the 6-minute series was normally fired; the 20-minute series was largely overfired with some shiner-scales; and the 60-minute series was dull, opaque, and reddish-brown in color over most of its area. A sample (marked 0) of the dried milled enamel was fused on platinum foil for 10 minutes. The fired enamels on

* Received September 17, 1937.

[1] Karl Kautz, "Reply to Staley's Discussion on 'A Critical Analysis of Some Statements and Experiments on the Adherence of Sheet-Steel Ground Coats,'" this issue, p. 311.

all samples were removed by flexing or bending double, carefully collecting all removed glass particles.

### III. Metallic Particles in Fired Ground Coats

Microscopic examinations of cross-sections of fired ground-coat enamels on iron always show free particles of metal imbedded in the glass near the interface. When the enamel is removed by flexing, these particles of course are removed with the glass. If the removed glass is ground exceedingly fine, these particles are largely freed or released from the glass matrix. Solution of these particles by appropriate reagents is then possible and consequently the determination of their chemical identity.

Methods for dissolving iron from mixtures containing oxides and slag are well known. In this case, however, the problem is more complicated because ground-coat glasses are slightly water-soluble and are even more soluble in acid solutions.

Three methods were chosen for investigation as follows:

(1) Treatment with excess iodine in ice-cold, air-free water under an inert atmosphere (method of Eggertz).[2] Under this treatment, metals combine directly with iodine to form soluble iodides, but oxides and slag are unaffected.

(2) Treatment with a solution of mercuric chloride (method of Wilner-Merck).[3] By electrochemical displacement, metals higher than mercury in the electromotive series form soluble chlorides precipitating free mercury. Oxides and slags are unaffected.

(3) Treatment with a solution of cupric sulfate (method of Cheesbrough).[4] This solution acts in the same manner as mercuric chloride.

Blanks were run by these three methods separating iron from iron oxides, cobalt from cobalt oxide, and nickel from nickel oxides, in which all methods worked very well. Ground-coat enamel fired on platinum was treated by the three methods. Considerable solution of the glass resulted with method (1) (treatment with iodine). The other two methods showed only a small attack on the ground-coat glass. Method (3) (cupric sulfate) was chosen to be the most convenient to use and the one from which excess reagent could easily be removed.

#### (1) Procedure*

The removed ground-coat glass particles were ground fine in an agate mortar. A one-gram sample was then digested with 50 milliliters of a 1% cold solution of $CuSO_4 \cdot 5H_2O$ for one hour, with frequent shaking. The solution was filtered and the residue thoroughly washed. The filtrate contained $CuSO_4$ and possibly $FeSO_4$, $NiSO_4$, and $CoSO_4$.

(*a*) Copper was removed electrolytically by plating on platinum electrodes from an acid solution.

(*b*) Iron was removed from the solution by oxidizing with bromine and precipitating with $NH_4OH$ as $Fe(OH)_3$. The precipitate was filtered, washed, and redissolved in HCl. The resulting solution was reduced by $SnCl_2$ and titrated with $N/10$ $KMnO_4$.

(*c*) Nickel was removed from the solution (ammoniacal) by precipitating with an alcoholic solution of dimethyl glyoxime. Nickel may be determined by weighing the washed and dried precipitate as nickel dimethyl glyoxime, by igniting the precipitate and weighing as NiO, or by dissolving the precipitate in HCl and titrating with standard KCN solution.

(*d*) Cobalt was removed from the solution (slightly acid) by precipitating with an acetic acid solution of nitroso-beta-naphthol. The precipitate was ignited and weighed as $Co_3O_4$.

### IV. Free Ferrous Oxide Adhering to Removed Ground-Glass Particles

Ferrous oxide may be dissolved selectively from mixtures containing FeO, $Fe_3O_4$, and $Fe_2O_3$ by cold weak solutions of sulfuric or hydrochloric acid. Determinations were run on ground-coat glass particles using cold 1% HCl solution, cold 1% $H_2SO_4$ solution, and boiling 10% citric acid solution. The $H_2SO_4$ solution was found to give the best results with the least solution of ground-coat glass. To determine the extent that a cold 1% $H_2SO_4$ solution attacks FeO dissolved in the glass, two identical samples were treated,

[2] A. A. Blair, Chemical Analysis of Iron, p. 78, 7th ed. J. B. Lippincott Co., 1912.

[3] F. P. Treadwell and W. T. Hall, Analytical Chemistry, p. 611. John Wiley & Sons, Inc., 1915.

[4] E. W. Cheesbrough, "Estimation of $Fe_2O_3$ and $Fe_3O_4$ in Presence of Fe and FeO," *Chemist-Analyst*, **20** [3] 14 (1931).

* Under Procedure is given only the general methods for analysis. For detailed analytical procedure, reference should be made to standard analytical texts, as this paper does not include all precautionary measures necessary to successful analysis.

one for $^1/_2$ hour and the other for 3 hours. These showed 2.51% FeO and 3.27% FeO, respectively, from a glass containing a total content of 9.24% FeO. Thus, when the time of digestion was increased six times, the FeO content was found to be only 1.3 times that of the original. It is permissible, therefore, to assume that the $^1/_2$-hour treatment dissolved practically all the free FeO with only a slight attack on the FeO in solution in the glass.

### (1) Procedure

The washed residue from the cupric sulfate digestion (from which metallic particles were removed) was digested with 100 milliliters of a cold 1% $H_2SO_4$ solution for $^1/_2$ hour, filtered, and washed. The solution was titrated directly with $N/10$ $KMnO_4$, and the ferrous iron was calculated to FeO.

## V. Total Iron, Nickel, and Cobalt Oxides in Removed Ground-Coat Particles

These metallic oxides may exist in the glass in different degrees of oxidation. Iron oxide, depending upon the degree of firing, may exist in the glass layer as FeO, as $FeO + Fe_3O_4$, or even as $FeO + Fe_3O_4 + Fe_2O_3$. Nickel oxide may exist as NiO or as $NiO + Ni_2O_3$. Cobalt oxide may exist as CoO or as $CoO + Co_3O_4$. No attempt was made to ascertain the state of oxidation of these metallic oxides; the quantities found were expressed as the monoxides, FeO, NiO, and CoO.

### (1) Procedure

A sample of the finely ground, removed fired ground coat was fused in a platinum crucible with a large excess of $Na_2CO_3$. The melt was dissolved in $HCl + HNO_3$, and after removing silica, the iron separated from the solution by $NH_4OH$. The nickel was separated by dimethyl glyoxime and the cobalt by nitroso-beta-naphthol. The results were expressed as FeO, NiO, and CoO, from which the equivalent amounts of the oxides of the previously determined metallic particles were deducted.

## VI. Metallic Nickel and Cobalt Content on the Iron Surface after Removing Ground-Coat Glass

Regardless of how much the sheet iron is flexed and bent, it is impossible to remove all of the minute oxide and glass particles still clinging to the surface. To determine the nickel and cobalt content on the surface, it was necessary, therefore, to use a reagent which would not attack the oxide or glass particles still attached. A solution of cupric sulfate was found to do this, taking into solution by electrochemical displacement only the metallic iron, nickel, and cobalt. Difficulties were encountered, however, when quantitative measurements were attempted. The loss in weight of the treated sample could not be determined accurately because the adhering particles of oxides and glass dropped from the sample during solution and metallic copper was deposited on the sample and in the bottom of the beaker. No attempt was made to determine the quantity of iron in the solution, but careful qualitative determinations were made for nickel and cobalt.

### (1) Procedure

Samples of the iron base (cut into one-inch squares) from which practically all of the ground-coat glass had been removed, were digested with 100 milliliters of a cold solution containing 1% $CuSO_4 \cdot 5H_2O$ for one hour and then filtered. Copper was removed from the solution electrolytically, and the iron by $NH_4OH$. Nickel and cobalt were determined qualitatively in the same manner as previously described for metallic particles in ground-coat glass.

## VII. Results of Chemical Analyses

The following tables give the results obtained by the chemical methods described.

TABLE I

METALLIC PARTICLES IN REMOVED GLASS PARTICLES

| | Minutes fired on iron | | | |
|---|---|---|---|---|
| | 2 | 6 | 20 | 60 |
| Fe (%) | 0.17 | 0.34 | 0.22 | 0.17 |
| Ni (%) | Slight trace | Trace | Slight trace | Nil |
| Co (%) | Nil | Nil | Nil | Nil |

TABLE II

FREE FeO IN REMOVED GLASS PARTICLES

| | Minutes fired on iron | | | |
|---|---|---|---|---|
| | 2 | 6 | 20 | 60 |
| FeO (%) | 3.38 | 2.51 | 2.45 | 3.02 |

TABLE III

TOTAL OXIDES OF IRON, NICKEL, AND COBALT IN REMOVED GLASS PARTICLES

| | Fired on platinum | Minutes fired on iron | | | |
|---|---|---|---|---|---|
| | 0 | 2 | 6 | 20 | 60 |
| FeO (%) | 0.22 | 7.77 | 9.24 | 17.62 | 37.31 |
| NiO (%) | 0.54 | 0.56 | 0.52 | 0.51 | 0.39 |
| CoO (%) | 0.40 | 0.40 | 0.38 | 0.33 | 0.30 |
| Other ingredients (% by difference) | 98.84 | 91.27 | 89.36 | 81.54 | 62.00 |

TABLE IV

METALLIC NICKEL AND COBALT ON IRON SURFACE AFTER REMOVING GLASS

| | Minutes fired on iron | | | |
|---|---|---|---|---|
| | 2 | 6 | 20 | 60 |
| Fe (%) | Not determined | | | |
| Ni (%)* | Slight trace | Slight trace | Slight trace | Slight trace |
| Co (%) | Nil | Nil | Nil | Nil |

* The amount of nickel was unweighable, being only a coloration of the filter paper when the solution was filtered.

## VIII. Discussion of Results

The metallic particles in fired ground coats were found to be essentially iron with only a trace of nickel. Because the iron base contained 0.07% Ni, it is likely that the trace of nickel found came from the iron base. This would be expected if the metallic particles were residual iron particles.

Free ferrous oxide was found in all stages of firing. These determinations were, perhaps, only approximately correct because of the soluble nature of ground-coat glasses. It was difficult to find a reagent which would dissolve free FeO without attacking the FeO dissolved in the glass.

The determination of total oxides of iron, nickel, and cobalt in removed ground coats presents no chemical difficulties; standard methods of analysis are satisfactory. When this analysis is recalculated so that undetermined ingredients represent 100 parts glass, the increase of iron oxide with firing time is readily apparent.

TABLE V

RECALCULATED ANALYSIS

| | Recalculated analysis (parts per hundred parts glass) | | | | |
|---|---|---|---|---|---|
| | 0 | 2 | 6 | 20 | 60 |
| FeO | 0.23 | 8.52 | 10.28 | 21.59 | 60.17 |
| NiO | 0.55 | 0.61 | 0.58 | 0.62 | 0.63 |
| CoO | 0.41 | 0.44 | 0.41 | 0.40 | 0.48 |
| Glass | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

It will be noticed that the FeO content is roughly proportional to the firing time. At the so-called "burnt" stage, 100 parts of glass pick up 60 parts of FeO. This, however, is not a true solution of FeO, but is made up both of free and dissolved FeO, $Fe_3O_4$, and $Fe_2O_3$. $Fe_3O_4$ probably is present in all stages of firing to some degree.

This recalculated analysis also shows that the quantity of NiO and CoO orginally present remains practically constant during all stages of firing. If electrochemical plating occurred, the amounts of NiO and CoO dissolved in the glass would be substantially decreased during firing on iron.

The iron surface, after removing practically all the fired ground-coat enamel, shows by careful qualitative determinations only a trace of metallic nickel and no metallic cobalt to be present. The nickel could easily have come from the iron base which contained 0.07% Ni. The absence of any appreciable amount of metallic nickel and the total absence of metallic cobalt on the iron surface during any stage of firing show that electrochemical plating either did not occur at all or occurred to an unmeasurable extent.

## IX. Ferrous Oxide Film under Fired Ground Coats

Because the amount of free FeO adhering to the glass particles can be approximately determined, a calculation of the thickness of the FeO film under fired ground coats is possible. For example, at the 6-minute stage of firing 2.51% free FeO was found. The pieces were originally dipped at 36 grams per square foot (dry dip weight, two surfaces). The loss after firing, assuming the only loss to be the dehydration of 7% clay and ¾% borax, would be

$$36 \times 0.985 = 35.46 \text{ g./sq. ft.}$$

$$\text{Therefore, } \frac{35.46}{288} = 0.1232 \text{ g./sq. in. (single surface).}$$

$$\text{Then } \frac{0.1232}{6.45} = 0.0191 \text{ g./sq. cm. (single surface).}$$

Therefore, one square centimeter of fired ground coat (one side) in the cited case would weigh 19.1 milligrams if there had been no absorption of iron oxide. This 19.1 milligram of glass, however, has absorbed 9.24% FeO, so the total weight of the glass layer plus the absorbed FeO would be $\left(\frac{19.1}{90.76} \times 100\right) = 21.05$ milligrams. The weight of free FeO involved would be

$$(21.05 \times 2.51\%) = 0.53 \text{ mg. per sq. cm.}$$

The specific gravity of FeO is 5.70; therefore

$$\frac{0.53}{5.70} = 0.093 \text{ cu. mm. of FeO,}$$

which is equivalent to a layer of 100 sq. mm. (1 sq. cm.) having a thickness of 0.00093 millimeter, or $\left(\frac{0.00093}{25.4}\right) = 0.000036$ inch thick.

This shows the average thickness of the FeO film to be approximately 0.00003 inch, a figure well within the range observed by visual microscopic methods.

### X. Summary

Chemical methods have been carefully investigated and are described for determining (1) the metallic particles in fired ground coats, (2) the free FeO between glass and iron, (3) the total FeO, NiO, and CoO in fired ground coats, and (4) the Ni and Co content on the iron surface after removing the glass.

The results obtained show that (1) metallic particles present in fired ground-coat layers are composed essentially of iron with a trace of nickel, (2) free FeO exists between the glass and iron in amounts dependent upon the firing treatment, (3) the total FeO content of the glass increases with firing time, but the NiO and CoO content remains practically constant, and (4) no metallic cobalt and only a trace of metallic nickel is present on the iron surface on which ground coat enamels have been fired.

**Acknowledgment**

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Massillon, Ohio

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# REPLY TO STALEY'S DISCUSSION OF "A CRITICAL ANALYSIS OF SOME STATEMENTS AND EXPERIMENTS ON THE ADHERENCE OF SHEET-STEEL GROUND COATS"*

By Karl Kautz

Author's Note: Because Staley's discussion[1] of Lord's paper is largely a discussion of the writer's paper,[2] it seems appropriate that a rather comprehensive reply be made.

### I. Volatilizing and "Burning Up" of Ground-Coat Enamels

In discussing the firing of colorless ground coats, Staley[3] states, "It was not until the enamel had been burned up and largely volatilized that black spots appeared." This idea of "burning up" and volatilizing is interesting. It seems improbable that ground-coat enamels, originally smelted for a number of hours at temperatures near 2300°F, should volatilize to a considerable degree at temperatures near 1600°F. In a recent paper,[4] the writer gave results of determinations of loss in weight of ground-coat frits fired at enameling temperatures. These results show that the loss in weight (due undoubtedly to the volatilization of some constituents) of commercial ground-coat frits is practically negligible at 1600°F. Because dried milled enamels contain 93 to 94% of these frits, the loss of applied enamels should also be very low. It is admitted that milled enamels containing clay, borax, and magnesium carbonate and applied in thin layers over large surface areas should have a much higher initial loss during the early stages of firing, but after dehydration and decarbonization have taken place the loss in weight should be but slightly greater than the results on frit.

### II. Chemical Analyses of Fired Ground Coats

The analyses of fired ground-coat enamels reveal some interesting facts.[5] For these determinations see Tables I to IV, this issue, pp. 309 and 310.

### III. Metallic Particles in Fired Ground Coats

The metallic particles were found to be essentially iron. This checks the results obtained by Spencer-Strong and King[6] by X-ray methods on commercial cobalt ground-coat enamels. The slight trace of nickel found in some of the samples undoubtedly came from the enameling iron base,

* Received July 30, 1937.

[1] H. F. Staley, "A Critical Analysis of Some Statements and Experiments on the Adherence of Sheet-Steel Ground Coats, Discussion of Lord Paper," *Jour. Amer. Ceram. Soc.*, **20** [4] 121–24 (1937).

[2] Karl Kautz, "Further Data on Enamel Adherence," *ibid.*, **19** [4] 93–108 (1936).

[3] H. F. Staley, "Electrolytic Reactions in Vitreous Enamels and Their Relation to the Adherence of Enamels to Steels," *ibid.*, **17** [6] 163–67 (1934); p. 166.

[4] Karl Kautz, "Random Experiments on Enamel Adherence," this issue, p. 303.

[5] Karl Kautz, "Chemical Determinations of the Metallic Particles and the Oxides of Iron, Nickel, and Cobalt in Fired Ground Coats," this issue, p. 307.

[6] G. H. Spencer-Strong and R. M. King, "Mechanics of Enamel Adherence: IX," *Jour. Amer. Ceram. Soc.*, **17** [7] 208–14 (1934).

which contained 0.07% Ni. A slight trace of nickel would naturally be expected if the metallic particles were residual base iron as suggested by the writer. It is worthy of note that not even a faint trace of metallic cobalt was found in any of the samples.

## IV. Free Ferrous Oxide in Fired Ground Coats

The chemical analyses show free FeO in all stages of firing, with the greatest concentrations in the early and highly advanced stages of firing. FeO dissolved in the enamel glass plus $Fe_3O_4$ and $Fe_2O_3$, either free or dissolved, may be obtained by difference from the total iron oxides in the glass particles. The fact that free FeO was found in all stages of firing lends further support to the importance of this compound in the adherence of enamels.

## V. Primary and Secondary Oxidation in Firing Ground-Coat Enamels

The theory which proposes a grippable surface, protected by an electrochemical plate of cobalt and nickel, must necessarily admit that a state of equilibrium exists after the ground coat is normally fired and that no further oxidation takes place. Concerning this, Staley says[7] "..... the plating and gripping theory admits the necessity for an initial film of oxide of iron on the surface of the steel but does not call for any further oxidation of iron by the kiln gases."

When ground coat, which has been fired excessively (the so-called "burnt" stage), is considered, it seems impossible of explanation by the plating and gripping theory. If all previous work be disregarded and only the chemical analyses be considered, the effect of oxidation is at once apparent (see tables I to IV, pp. 309 and 310, this issue).

To demonstrate more clearly the increase in iron-oxide content of fired ground coats with firing time, the analysis of glass particles was recalculated, assuming the undetermined ingredients to represent 100 parts of glass. This can be done without introducing appreciable error, because, as stated previously, the volatilization loss of ground coats fired at 1600°F is low.

This recalculated analysis shows clearly the relation between firing time and the iron-oxide pick-up of a constant quantity of glass. It seems desirable to divide the oxidation occurring in the firing of enamels into two parts: (*a*) *primary oxidation* of the iron surface, which takes place during the "heating up" of the iron base prior to fusion of the glass particles (this oxidation, of course, is due to aerial oxygen) and (*b*) *secondary oxidation* of the iron surface, which takes place after fusion of the glass particles.

In the first 2 minutes of firing, the FeO content increased from 0.23 part per hundred parts glass to 8.52 parts (increase of 8.29), due principally to primary oxidation. Between 2 minutes and 6 minutes, the FeO content increased 1.76 parts by secondary oxidation. Between 20 minutes and 60 minutes, the FeO content appears to be a straight-line function of the firing time. From 2 minutes up to the 60-minute stage, the FeO content is almost directly proportional to the firing time. How can this be?

Staley[8] says "As cobalt and nickel oxides are plated out as metal, chemically equivalent amounts of iron are oxidized. This will produce considerable oxide of iron in the layer of enamel adjacent to the metal base." Staley has never stated at what stage of firing this electrochemical plating occurs. One could not expect this to occur during the first 2 minutes of firing because the glass particles are not molten and primary oxidation is taking place. If the electrochemical plating occurs between 2 minutes and 6 minutes, that is, from the time the glass layer becomes molten up to the time good adherence is developed, then it must account in the foregoing typical case for an increase of 1.76 parts FeO according to the reactions,

$$Fe + CoO \text{ (glass solution)} \rightarrow FeO \text{ (glass solution)} + Co$$

and

$$Fe + NiO \text{ (glass solution)} \rightarrow FeO \text{ (glass solution)} + Ni.$$

Even if the entire NiO and CoO content of the molten glass layer in the cited case could, in

| | | Recalculated analysis (parts per hundred parts glass) | | | | |
|---|---|---|---|---|---|---|
| | | 0 | 2 | 6 | 20 | 60 |
| Undetermined ingredients calculated on basis of 100 parts glass exclusive of iron, nickel, and cobalt oxides | FeO | 0.23 | 8.52 | 10.28 | 21.59 | 60.17 |
| | NiO | 0.55 | 0.61 | 0.58 | 0.62 | 0.63 |
| | CoO | 0.41 | 0.44 | 0.41 | 0.40 | 0.48 |
| | Glass | 100.00 | 100.00 | 100.00 | 100.00 | 100.00 |

[7] See p. 123 of footnote 1.

[8] See footnote 7 on p. 121, of footnote 1.

some unexplainable manner, migrate to the iron base and react 100%, there would be formed only 0.92 part FeO and not 1.76. Then what would happen when it is subjected to further firing? The entire amount of CoO and NiO would have already imparted its oxygen to the iron base, and no further oxidation could possibly take place. This, as shown above, is contrary to the facts.

It seems that the electrolytic potential theory offers no explanation for the facts of secondary oxidation. How then can secondary oxidation be explained? The only plausible explanation is that aerial oxygen by some *unknown mechanism* is continuously carried through the molten glass layer to the iron surface.

This recalculated analysis also brings out one other pertinent fact, namely, the constancy (within chemical error) of the NiO and CoO content of the glass. Throughout the various stages of firing, the NiO and CoO content of the glass remained practically constant. This also is a contradiction of the electrolytic potential theory because the NiO and CoO content should be materially decreased during firing, if it functions at all.

## VI. Analysis of Iron Surface after Removing Fired Ground Coats

This analysis showed principally iron with only a slight trace of nickel. Not even a faint trace of metallic cobalt was found during any stage of firing. The trace of nickel found can readily be explained as coming from the residual iron base which contained 0.07% Ni.

## VII. Reduction of Copper-Bearing Glasses

The most substantial proof of "electrolytic potential reactions" ever presented by Staley[9] was the behavior of copper-bearing glasses fired on iron. It was unfortunate that the theory of "electrolytic potential reactions" should be based on the chemical behavior of copper. Compounds of copper exhibit some peculiar characteristics, especially when heated. Cupric oxide (CuO) when heated is readily decomposed into cuprous oxide and oxygen according to the reaction,

$$4CuO \rightleftarrows 2Cu_2O + O_2.$$

The reaction depends upon the temperature and the partial pressure of oxygen and can be made to proceed in either direction. If oxygen is removed, the reaction proceeds to completion from left to right.

[9] See p. 166 of footnote 3.

During a chemical reaction, chemical energy is transformed into an equivalent amount of some other form of energy which is usually, though not always, heat. Under certain conditions, with ionized melts or solutions, the chemical energy may appear as electrical energy, and the reactions may accordingly be exo-electrical or endo-electrical. With solid-phase reactions of the type,

$Fe_2O_3 + 2Al \rightarrow Al_2O_3 + 2Fe$ (Goldschmidt thermite process),

there is a tremendous amount of heat evolved. Cupric oxide reacts in a similar manner with iron when heated (this is one method of preparing FeO) according to the reactions,

$$CuO + Fe \rightarrow FeO + Cu$$
$$2CuO + Fe \rightarrow FeO + Cu_2O.$$

It also can react with FeO,

$$2CuO + 3FeO \rightarrow Fe_3O_4 + Cu_2O.$$

In other words, cupric oxide at high temperatures is a strong oxidizing agent because it readily oxidizes iron or ferrous oxide, the reactions being of the thermal type.

In explaining the reduction of copper-bearing glasses, the writer[10] has already taken up the important rôle that reducing gases evolved from the iron base play in this reduction. The cupric oxide in solution in the glass acts as an oxidizing agent because it oxidizes the gases and is thereby reduced either to cuprous oxide or metallic copper.

Experiments recently published[4] show that borax glasses containing CuO in solution are reduced to red cuprous oxide or metallic copper, or both, when heated in contact with FeO, NiO, CoO, and MnO, but are unaffected by higher, oxides such as $Fe_2O_3$, $MnO_2$, or $NiO_2$.

The glass solutions of cupric oxide may be regarded as being highly oxidizing, or the monoxides of manganese, iron, nickel, and cobalt may be regarded as being highly reducing. In either case, oxidation and reduction are closely associated, and one can not take place without the other.

Because molten glass solutions of cupric oxide are oxidizing, cuprous oxide or copper would be formed from these glasses by any compound, or element, which is readily capable of taking up oxygen preferentially to copper. The reaction.

Fe + CuO (glass solution) → FeO (glass solution) + Cu,

probably is not an electrolytic potential reaction

[10] Karl Kautz, "Discussion on Lord's Paper," *Jour. Amer. Ceram. Soc.*, **20** [4] 117–19 (1937).

at all but the familiar oxidation-reduction reaction of chemistry.

Recently published experiments[9] show that copper-bearing glasses are reduced by commercial sheet iron, the reduction being due partly to evolved gases from the iron, partly to FeO formed at the iron surface, and partly to metallic iron itself.

Staley has offered no evidence that (1) molten glass solutions of cupric oxide are strongly ionized solutions, and (2) in the reduction of metallic copper from these molten glasses, electrical energy is either liberated or absorbed.

## VIII. Experiments in Enameling Chromium, Iron, Nickel, and Copper

When the writer[11] performed these simple experiments, it was understood that commercial cobalt ground-coat enamel, especially developed for iron, was the basis for comparison. It was expected, furthermore, that other factors, "such as the structure of the metal surface, presence of oxide on the surface, coefficient of thermal expansion of the metal, etc.," influenced adherence, to some degree, but if the electrolytic potential theory was operative in producing adherence it should still give some indications in these simple tests.

That iron may be enameled and nickel may not fits well with the electrolytic potential theory, but that chromium may not be enameled and copper may be is altogether contradictory to the theory. Although no explanation can be found for this anomalous behavior in the electrolytic potential theory, the behavior of these metals during oxidation offers some possibilities.

Iron, when heated, is readily oxidized, and the FeO formed is quite soluble in ground-coat enamels and slightly soluble in iron. The point of weakness would therefore be between FeO and iron, and particles of removed glass (when examined microscopically) actually show scale adhering to the glass. Copper, when heated, is more easily oxidized than iron, and the $Cu_2O$ formed is sparingly soluble in glasses but extremely soluble in copper. Oxygen actually alloys with copper as though it were a metal. The point of weakness, therefore, would occur between the glass and $Cu_2O$, and particles of removed glass, when examined microscopically, show mostly clear glass fragments with occasionally an extremely thin film of $Cu_2O$ attached. The copper base under the removed glass shows large amounts of $Cu_2O$ dissolved in the copper.

Both nickel and chromium, when heated, are difficult to oxidize. NiO is practically insoluble in nickel and is not greatly soluble in glasses. Chromous oxide (CrO), which forms first, is immediately oxidized to $Cr_2O_3$ which is practically insoluble in chromium. $Cr_2O_3$ also is only slightly soluble in glasses. In these cases, the oxides which form have almost no solubility in the metal and poor solubility in the glasses. Accordingly, thick, brittle layers of scale form during firing and thus nothing but poor adherence could be expected.

## IX. Grippable Surface Theory

Regardless of how carefully the iron surfaces are pickled or prepared, cobalt ground-coat enamels will not wet or adhere when fired in reducing or inert atmospheres. Here the original grippable surface is preserved, but adherence is practically nil. It might be said that a deeply pickled surface in the presence of oxygen functions to produce good adherence, but in the absence of oxygen it functions only weakly or not at all.

In a recent paper by the writer,[12] photomicrographs clearly show that the surface after normally firing a cobalt ground coat is of a different type than the one originally prepared. In firing the ground coat, the original surface is largely destroyed and a new one is created. This new surface appears to be similar in all cases, regardless of the original surface preparation. In other words, the carefully prepared grippable surfaces (either by chemical or mechanical means) are altered by oxidation during the firing of the ground coats. Primary oxidation almost destroys the originally prepared surface, and secondary oxidation completes the destruction. If gripping plays a part in the adherence of enamels to iron, it surely is not the preserved pickled surface which functions but rather the irregular surface produced by secondary oxidation.

## X. The Pickling of Iron

Staley says that deep pickling of the ferrous sheet is the principal cause of good enamel adherence, without any qualifying statements as to the furnace atmospheres, rate of heating, composi-

[11] See pp. 94 and 95 of footnote 2.

[12] Karl Kautz, "Effect of Iron Surface Preparation upon Enamel Adherence," *Jour. Amer. Ceram. Soc.*, **20** [9] 288–95 (1937).

tion and physical condition of the ground coat, or the grade of ferrous sheet. Surely the method of sheet manufacture (its previous rolling, annealing, and pickling treatments) has a bearing on whether the sheet should be pickled lightly or deeply before enameling. Excessive pickling is often detrimental to commercial enameling setups and some enamelers prefer a very light pickle.

The writer agrees with Staley that pickling helps to increase adherence in addition to etching it or making it rough.

Here are some of the things deep pickling in hot dilute sulfuric acid does: (1) it produces a rough or etched surface on the iron (microscopically the surface appears to consist of tiny hemispherical pits of various sizes); (2) it makes the iron at the surface spongy and very porous; (3) it produces occlusion of atomic hydrogen in the iron; (4) it produces an adsorption (and probably some absorption) of free acid and ferrous sulfate ($SO_4$ radical) at the surface; (5) it produces a concentration of insolubles on the surface (this film, commonly called "pickler's black," is composed principally of copper, with smaller amounts of iron carbides, nickel, and manganese); (6) it removes the tight, strained surface skin produced by severe cold deep drawing or rolling; (7) it removes minute rust pits from the surface, if present; (8) it removes "rolled-in" magnetite scale from the surface, if present; (9) it removes microscopic ferrous-oxide inclusions exposed at the surface of the ferrite grains; and (10) it releases imbedded dirt and grease from the surface, if present.

Increased enamel adherence *may be* caused by (1) the honeycomb surface structure, (2) the spongy iron surface layer, (3) the hydrogen occlusion, or (4) a general cleaning or purification of the surface.

The adherence of thin oxide coatings to iron may be tested with the same impact device used for testing enamel adherence. In studying the adherence of oxide coatings (produced at 1300°F for 5 minutes), it was found that any treatment which produced good adherence of oxide to iron also produced good adherence of enamel, *i.e.*, the adherence of thin oxide films to iron seems to parallel the adherence of ground-coat enamels to iron. The most remarkable adherence of oxide coatings and fired ground-coat enamels was found on unpickled samples which had a smooth, but deep, spongy iron surface layer.

It might be that the roughness or extremely large surface area of deeply pickled iron materially aids in the adherence of oxide coatings and thus of enameled coatings. The writer believes that spongy iron at the surface of deeply pickled iron plays an important rôle.

## XI. Summary

In seeking the answer to this vexing problem of enamel adherence, investigators are now confronted by a number of theories. The writer, in summarizing, would like to dispense with the electrolytic potential theory for the following reasons:

(1) No evidence has ever been found, either by X-ray or chemical methods, that the metallic particles in commercial ground-coat enamels fired on iron are composed of cobalt or nickel as required by this theory.

(2) No evidence has been found by chemical methods that the iron base under the fired ground enamel is plated with metallic cobalt or nickel.

(3) Chemical analyses of removed ground coats fired on iron show that the nickel and cobalt oxide content of the enamel remains practically constant during all stages of firing.

(4) The electrolytic potential theory fails to explain secondary oxidation of the iron surface during the firing of the ground coats.

(5) The reduction of copper-bearing glasses fired on iron (the physical basis for the electrolytic potential theory) has been shown probably to be due to oxidation-reduction reactions, in which reducing gases, ferrous oxide, and probably metallic iron play a part.

(6) The electrolytic potential theory fails to explain the enameling behavior of commercial cobalt ground-coat enamels on chromium and copper. The behavior of these metals with oxygen, however, makes possible an explanation.

(7) No evidence has ever been presented to show that molten commercial ground-coat enamels or copper-bearing glasses are strongly ionized solutions.

(8) No evidence has ever been presented to show that free electrical energy is involved in the reduction of copper-bearing glasses fired on iron.

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# GRINDING DRY-PROCESS ENAMEL AND ITS EFFECT ON WORKING PROPERTIES*

By M. E. Manson

Abstract

The degree of grinding dry-process enamels has a marked effect on the packing of powder on the balls and mill walls, on the loss due to convection currents during the dusting operation, and on the ease with which the powder goes through a vibrating screen. The use of small amounts of water in the mill during grinding is beneficial to all these powder characteristics.

## I. Introduction

During recent years, a great deal of work has been done on the effect of various grinding procedures on the working properties of enamel slips, so that today the milling of wet enamels is a fairly well-standardized process. Practically no work has been reported during this period, however, on the grinding of dry-process enamels.

Cooke,[1] in 1935, mentioned the advisability of adding a small amount of water to the mill for dry grinding, but he did not go into detail.

It is current practice among dry-process plants, where batch mills are used, to load the mill one-half full of balls and one-quarter full of frit. Grinding is then continued until the powder feels right when rubbed between the fingers. Where Hardinge mills are used, the rate of feed is adjusted to the point at which the discharged powder feels right.

## II. Experimental

For this investigation, a 100-pound bag of dry-process frit was thoroughly mixed and all experimental millings were made using this frit. A laboratory mill was used for all tests, which held 4 pounds of frit when charged according to commercial practice. Throughout the entire series of experiments, the ball charge remained the same.

A series of millings was run first with no water addition and with the time of grinding varied to give a series of powders, ranging from much finer than commercial practice to much coarser. This was followed by a series of millings to which a small amount of water had been added. On each mill run five tests were made as follows:

(1) The amount of enamel clinging to the balls, cover, and mill walls, after moderately hard rapping, was brushed off and weighed.

(2) A screen analysis of the powder was made.

(3) The tendency of the powder to be carried away by convection currents was measured. In dry-process enameling, the heat of the casting being dusted sets up convection currents which carry away a large amount of enamel. Some plants have dust-collector systems to recover this enamel, but in a great many plants this is a total loss.

Because convection currents which were reproducible could not be set up, an apparatus was devised in which compressed air, held by a reducing valve at 20 pounds pressure, was led into a gas-stove burner. This burner sat on a large piece of paper and was inclosed by a chimney of the same diameter as the burner and 12 inches high. With the air turned on, there was a fairly well-diffused upward current of air at the top of the chimney. Fifty grams of powder were dusted through a small hand-vibrated sieve held directly above the chimney, and that portion which fell on the paper was weighed; the loss was expressed in percentage and was called convection current loss.

While this apparatus seems crude, results were reproduced on any given enamel within $^1/_2\%$.

(4) The speed with which the powder ran through a vibrating screen was determined. This is an important factor in dry enameling, for speeds which are too high or too low cause trouble.

An electric vibrator was securely fastened to a 40-mesh screen of 8-inch diameter. (In commercial practice, the enameling sieves are usually about 40-mesh.) Two pounds of powder were put in this screen, which filled it nearly to the top, and the weight of powder which went through in 10 seconds of vibration was measured.

(5) Sample plates were made and examined for opacity and texture, but no appreciable difference in these properties was noticed.

## III. Results

Eight samples were milled without the addition

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Enamel Division).

[1] R. D. Cooke, "Laboratory Control in Dry-Process Enameling," *Bull. Amer. Ceram. Soc.*, **14** [11] 373–74 (1935).

of water, and in Fig. 1 is shown the screen analysis of these powders on a set of screens composed of 100-, 150-, 200-, 270-, and 325-mesh. It is evident that these dry-ground enamels give about the same grain-size distribution curves as are obtained in wet grinding, but it is noticeable that as the coarseness increases, the curve flattens out until in No. 6 it is nearly a straight line.

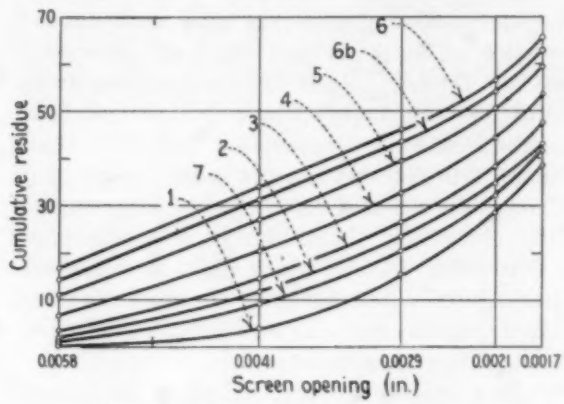


FIG. 1.—Frit milled without water.

Eight samples were next milled with the addition of water. To the first mill 0.5 cubic centimeter of water was added, to the next 0.75 cc., then 1.0 cc., and all others had 1.25 cc., which is equal to 31 cc. per 100 pounds of frit. As will be shown later, over a certain minimum, the actual

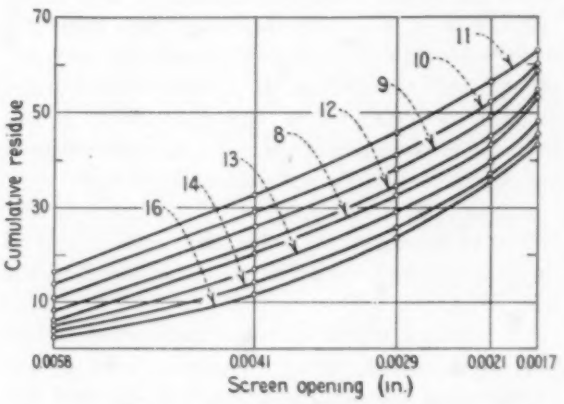


FIG. 2.—Frit milled with water.

amount of water had little bearing, the same results being obtained whether 0.75 cc. or 1.25 cc. was used. Figure 2 shows the grain-size distribution of these enamels as determined by screen analysis, and it is evident that the curves are nearly identical with those in Fig. 1, so that apparently the presence of moisture in the mill has not affected the grain-size distribution.

In Tables I and II these tests are listed with the fineness, expressed as percentage on 200-mesh, the percentage of the charge clinging to balls and mill walls, the convection current loss, and the weight of powder in grams put through the sieve by 10 seconds of vibration.

### (1) Enamel Clinging to Balls and Mill Walls

It is evident from Table I that as the fineness increases, more powder clings to the balls and wall, although the finest enamel (No. 1) in Table I shows only a loss of 0.75%. This does not seem

TABLE I
ENAMELS MILLED DRY

| Test No. | Fineness (% on 200-mesh) | Amount clinging to balls and mill walls (%) | Convection current loss (%) | Weight (g.) through sieve in 10 sec. |
|---|---|---|---|---|
| 1 | 15.50 | 0.75 | 14.6 | 521 |
| 7 | 20.25 | 0.56 | 13.0 | 562 |
| 2 | 23.50 | 0.33 | 12.1 | 584 |
| 3 | 26.60 | 0.33 | 10.6 | 590 |
| 4 | 32.60 | 0.14 | 9.8 | 562 |
| 5 | 39.50 | 0.14 | 7.4 | 534 |
| 6*b* | 43.50 | 0.06 | 8.0 | 587 |
| 6 | 46.20 | 0.06 | 10.4 | 686 |

to be a large amount, but it is probable that as the size of the mill increases, this loss increases. It has been noticed in one plant that, when using a Hardinge mill, such a layer of powder would build up on the walls that discharge would nearly stop, although a constant feed of frit was going into the charging end. As Table II shows, the presence of water in minute amounts nearly eliminated this difficulty, and, at the plant where the tests were run, it was found that throwing a few wet balls into the mill caused this cake on the walls to break loose and the mill to start discharging again.

### (2) Convection Current Loss

From an examination of Table I, it is evident that as fineness decreases the convection current loss decreases, as would be expected, until the very coarse enamels, 6*b* and 6, are reached, where the loss increases. Referring to Fig. 1, these two enamels have a fineness curve approaching a straight line. It is possible that this point is significant. This straight-line curve may indicate the complete absence of any packing effect, under which condition the fines are more easily separated from the coarse particles by convection currents.

This will be discussed further in connection with the manner in which the powder goes through the screen.

Table II shows that the presence of moisture in excess of the minimum used in No. 8 cuts this convection current loss down to a figure which does not vary much regardless of the degree of fineness. It will be noted that in addition to No. 8, which did not have enough water added to be

TABLE II
ENAMELS MILLED WITH WATER

| Test No. | Fineness (% on 200-mesh) | Amount clinging to balls and mill walls (%) | Convection current loss (%) | Weight (g.) through sieve in 10 sec. | Moisture (cc.) added to 4 lb. |
|---|---|---|---|---|---|
| 16 | 23.5 | 0.07 | 5.1 | 412 | 1.25 |
| 14 | 25.7 | 0.05 | 5.6 | 451 | 1.25 |
| 13 | 29.0 | 0.03 | 6.2 | 476 | 1.25 |
| 15 | 29.5 | 0.05 | 8.0 | 645 | * |
| 8 | 32.3 | 0.05 | 11.9 | 595 | 0.50 |
| 12 | 34.4 | 0.03 | 7.2 | 476 | 1.25 |
| 9 | 37.8 | 0.03 | 7.4 | 432 | 0.75 |
| 10 | 41.0 | | 7.4 | 415 | 1.00 |
| 11 | 45.4 | | 5.2 | 391 | 1.25 |

* Enamel ground to required fineness dry, then mill was opened and 1.25 cc. water added, mill closed, and ground 30 minutes longer.

of value, No. 15, which was ground dry but had water mixed into the powder, had a higher convection current loss than those in which the water

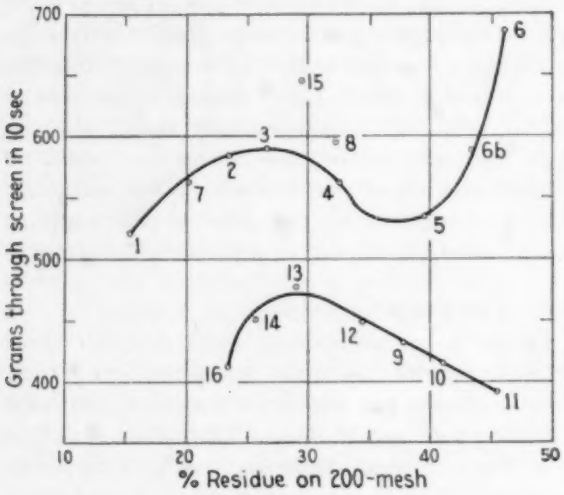


FIG. 3.

was added to the mill at the start. It would seem evident that an appreciable saving of enamel can be made by adding moisture to the mill.

### (3) Rate of Passing through a Vibrating Screen

The data on the rate of passing through a vibrating screen are given in Tables I and II and are also shown in Fig. 3.

The upper curve represents the enamels ground dry, and from points (1) to (5) is about what would be expected. When the enamel is ground very fine, as No. 1, the packing effect slows down its passage through the screen. As the fineness decreases, packing decreases until a maximum is reached at No. 3, beyond which the increase in average grain size seems to slow down the enamel until the very coarse enamels, Nos. 6*b* and 6, are reached, where the speed through the screen jumps straight upward. It would seem again that as the fineness curve approaches a straight line, a condition of no packing is approached, and a material is obtained which might be called "free flowing"; No. 6 seemed to go through the screen like a granular material in which all grains were smaller than the screen opening.

The lower curve represents all of the enamels ground with water except Nos. 8 and 15. Thus the addition of this small amount of water has slowed down the passage of the powder through the screen tremendously, and there is no sudden upturn when the straight-line fineness curve is reached. It is interesting to note that enamels Nos. 9 and 10 (in which only 0.75 and 1.00 cubic centimeter of water was used, as against 1.25 cc. in all the other samples) lie right on the curve.

But No. 8, with only 0.50 cubic centimeter of water added to the mill lies up with the enamels ground dry. Evidently, then, there is a minimum amount of water below which no effect is obtained, but once this is exceeded, the same results are obtained regardless of the water content.

Enamel No. 15 is apparently in a class by itself. It would appear that, if the beneficial effects of water are to be secured, it must be added to the frit.

One other curious fact was discovered in this part of the investigation. Some of these figures on the speed through the screen were checked and rechecked. The portion which went through was put back with the remainder of the powder and the batch was rolled on a paper to get, if possible, a thorough mixture again. When this was put through the screen again, the actual weight which went through dropped about 10 or 15 grams. This drop occurred every time this procedure was repeated, up to three times, with all of the enamels

except Nos. 6 and 6*b*, which gave identical results every time through the screen.

Some of these enamels milled with water were checked for speed through the screen after a period of two weeks standing in an open bag in the laboratory, and the same slight lowering of speed was noticed. It must be, therefore, that this slowing down of the screen speed by the addition of water to the mill is a permanent effect, which does not disappear after the enamel has a chance to dry out.

While it was easy to measure the speed of these enamels through the screen, there was no way to gage the most desirable speed. Enamels Nos. 1, 3, 6, 10, 13, and 16 were taken, therefore, to a commercial dry-process plant for experimental tests. Without knowing what the difference was, the enameler chose No. 13 as the best flowing enamel, and he expressed the opinion that Nos. 1, 3, and 6 were "too dusty."

In this plant, when enamel was milled with a water addition and used, the enamelers said that it seemed to melt down faster on the casting.

## IV. Conclusion

As a result of these tests, it would seem that the best milling practice, where batch mills are used, is to add about 1 ounce of water to the mill per 100 pounds of frit and grind to a fineness of about 30% on 200-mesh. This will give a minimum loss due to packing on the balls and mill walls, a minimum convection current loss, and the best workability through the sieve onto the ware.

Where Hardinge mills are used, the figure 30% on 200-mesh probably still holds good. The question of water addition, however, is more difficult. The addition of water will be a great aid, but how much to add and how to add it is not yet established. Because a Hardinge mill is open at both ends, more water may be needed than in a batch mill. One plant solves this problem by making it a routine duty for the millroom man to throw six wet balls into the discharge end every half hour. But because this present study shows that the effect of the addition of water to powder already milled is quite different from that of the addition of water to the frit, it would seem more desirable to work out some method for adding water to the frit as it enters the mill.

No explanation is offered for the marked effect of this water addition on the various properties of the powder, particularly on its tendency to go through a vibrating screen. It was thought that in grinding the frit dry, a film of air was adsorbed by the individual particles, which was displaced by a film of water when water was added to the frit. The fact that the properties of a powder ground dry were unchanged by evacuation in a vacuum flask and that the properties of powders ground with water did not change after prolonged air drying makes this theory seem doubtful.

Chicago Vitreous Enamel Product Company
Cicero, Illinois

# REFRACTIVE INDICES OF SOME GLASSES IN THE TERNARY SYSTEM $K_2O \cdot 4SiO_2$–$Fe_2O_3$–$SiO_2$*

By George T. Faust† and Albert B. Peck‡

Abstract

In the course of some phase-rule investigations of the ternary system $K_2O \cdot 4SiO_2$–$Fe_2O_3$–$SiO_2$ by the "quenching method" of Shepherd, Rankin, and Wright, the refractive indices of 30 glasses were measured by the usual petrographic immersion method. The refractivities varied from 1.438 for a $K_2O \cdot 7SiO_2$ glass to 1.621 for the most ferriferous glass which contained 32.3% $Fe_2O_3$. The maximum FeO content reached a value of 0.33% in a glass originally containing 25% $Fe_2O_3$. Along the sections $K_2O \cdot 4SiO_2$, $K_2O \cdot 5SiO_2$, $K_2O \cdot 6SiO_2$, and $K_2O \cdot 7SiO_2$, the relation between the $Fe_2O_3$ content of the glasses and the refractive index is apparently linear. The isofracts, however, in the ternary system are curved lines.

## I. Introduction

While investigating the phase relations obtaining in the ternary system, $K_2O$–$Fe_2O_3$–$SiO_2$, data on the refractive indices of homogeneous glasses were recorded. Because the results of the phase study have been published only in part[1] and it may be a year or so before the phase relations in the triangle, $K_2O \cdot 4SiO_2$–$Fe_2O_3$–$SiO_2$, will be completed for publication, the present data are recorded.

## II. Preparation of the Components

### (1) Silica

The silica was prepared from clean specimens of Sylvania sandstone,[2] collected by C. B. Slawson in March, 1931. This sandstone is one of exceptional purity, having an average iron-oxide content of 0.015%, according to Wright.[3] In the hand specimen, the rock resembles a lump of white sugar and is easily broken up by crushing between the fingers. Under the hand lens, the rock is seen to be made up of rounded, frosted grains of quartz of fairly uniform size, weakly cemented together by calcite. The "heavy minerals" occurring in the sandstone are scarce and the following[4] have been reported: celestite, garnet, pyrite, tourmaline, magnetite, and zircon.

The sugarlike grains were sieved through No. 52 bolting cloth and the undersize was treated with HCl to remove the calcite cement. The heavy minerals were separated from the quartz by means of bromoform. The quartz was boiled several times with a dilute HCl solution, containing a few drops of nitric acid, until a negative test for iron was obtained. Although this digestion removed the greater portion of the iron oxides, small amounts sometimes remained as adsorbed films of iron compounds in the cracks of the grains. To remove these traces, it was necessary to break up the grains. The washed and dried grains were then heated in a platinum crucible at 1450°C (approximately) for a period of ten to twelve hours. The quartz grains became powdery through the volume changes on inversion and shattered easily under a sharp blow. The powder, consisting principally of cristobalite, was then treated with the acid mixture (mentioned previously) to remove the small traces of iron compounds and any platinum deposited on the charge while in the furnace.

This material was analyzed by evaporating with hydrofluoric and sulfuric acids and igniting the residue with ammonium carbonate to constant weight. Two analyses gave 99.94 and 99.93% $SiO_2$.

A spectroscopic analysis was made by Kenneth B. Thomson, research spectroscopist, University of Michigan. Dr. Thomson's report is as follows:

> The quartz shows no strong lines other than those of silicon and two or three weak lines which are probably silicon lines but were not listed in the tables at hand.

### (2) The $K_2O$ Component

An especially pure lot of potassium bicarbonate[5]

* Presented at the Thirty-Ninth Annual Meeting, American Ceramic Society, New York, N. Y., March 23, 1937 (Glass Division). Received August 12, 1937.

† Department of Ceramics, Rutgers University, New Brunswick, N. J.

‡ Mineralogical Laboratory, University of Michigan, Ann Arbor, Mich.

[1] G. T. Faust, "Fusion Relations of Iron-Orthoclase with a Discussion of Evidence for the Existence of an Iron-Orthoclase Molecule in Feldspars," *Amer. Mineralogist*, **21** [12] 735–64 (1936).

[2] From the glass sand quarries of the Michigan Silica Co., Rockwood, Mich.

[3] F. E. Wright, "Manufacture of Optical Glass and of Optical Systems," *Ordnance Dept. Doc.*, No. 2037, p. 84 (1921); Washington, D. C.

[4] W. F. Hunt, oral communication, October 10, 1930.

[5] Analytical Reagent, Mallinckrodt Chemical Co.

was analyzed, according to the standard methods in Murray,[6] and was found to be satisfactory. The spectroscopic analysis by Dr. Thomson follows:

For the analysis of the $KHCO_3$, a solution was prepared containing 3 grams of $KHCO_3$, 5 cc. of HCl and distilled water to make up to 100 cc. This solution was run against a blank containing 5 cc. of HCl and 95 cc. of water and a known solution containing 0.05% Na, and in addition 0.01% Mg, 0.01% Mn, 0.005% Cu, 0.05% Ca, 0.3% K, all present as chlorides. The sodium in the $KHCO_3$, *if any*, is exceedingly small and judging by comparison with the standard solution containing 0.05% Na, the amount would be probably less than 0.01% of this value. Further, Mg, Ca, Fe, and Al lines were all absent.

### (3) The Ferric Oxide Component

To prepare the iron oxide, especially pure ferric ammonium sulfate was dissolved in water and slightly acidulated with nitric acid to make sure that all of the iron was in the ferric state. Ammonia gas was bubbled into the solution until the reaction was complete. The entire process was carried out in platinum vessels. The precipitate was filtered and washed with a hot, 1% solution of ammonium nitrate until a positive test for sulfate was no longer obtained. The dried mass was then heated in a porcelain crucible to a temperature below 1000°C, and the resulting product was examined microscopically and by means of the X-ray powder method to prove the absence of magnetite. The spectrographic analysis follows:

There is no evidence of any titanium in the ferric oxide preparation and only an exceedingly small amount of aluminum and silicon. The presence of the aluminum is, however, not definitely established.

## III. The Furnaces

The furnace employed was the standard Geophysical crystallizing furnace, the winding of which consists of 100 grams of 0.8 millimeter diameter, iridium-free platinum wire, containing 10% rhodium. The resistance of the platinum coil was found to be 3.3 ohms at 0°C and 7.5 ohms at 1000°C. The furnace coil was connected in series with resistances of 2, $2^3/_4$, and 6 ohms, respectively. Figure 1 shows the construction of the furnace[7]; Fig. 2 is a diagram of the furnace circuit.

[6] B. L. Murray, Tests for Reagent Chemicals, 2d ed. New York, 1927.

[7] T. F. Barry, technician in the Geophysical Laboratory, furnished the sketch from which the furnaces were constructed and the drawing was made.

## IV. Preparation of the Glasses

Glasses having the composition[8] of $K_2O \cdot 4SiO_2$, $K_2O \cdot 5SiO_2$, $K_2O \cdot 6SiO_2$, and $K_2O \cdot 7SiO_2$ were first compounded in the following manner: The requisite amount of silica was weighed into a platinum crucible and the potassium bicarbonate was weighed separately on a watch-glass. The two were care-

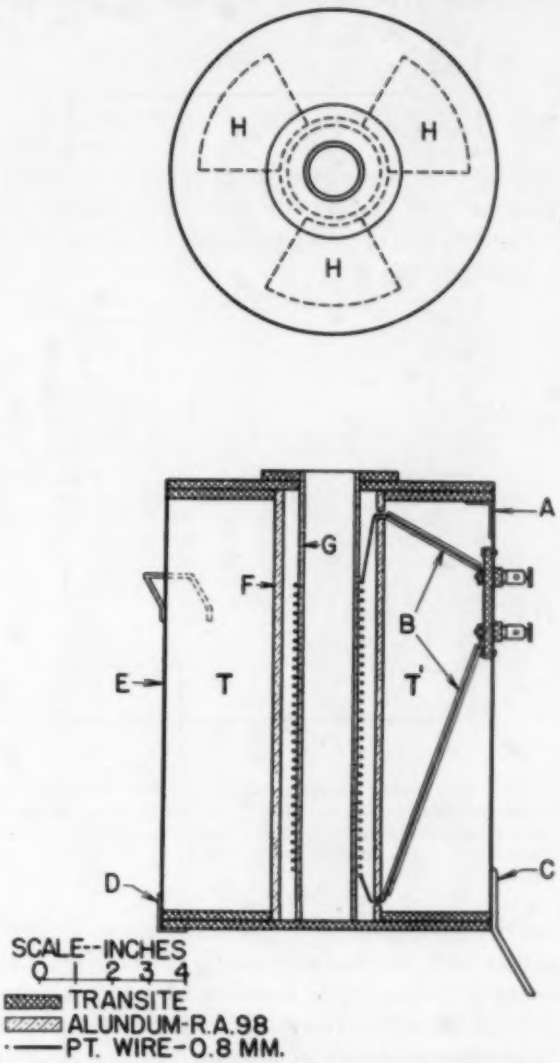


FIG. 1.—The Geophysical crystallizing furnace. *A* and *D*, brass supports; *B*, porcelain capillary tubes protecting the heating element; *C*, brass leg; *E*, brass sheet; *F* and *G*, Norton Alundum tubes; *H*, slots, in transite just above the support (these slots permit furnace to be packed with insulating material); *TT'*, volume between refractory tube and brass outer wall packed with fluffy MgO.

[8] This designation does not signify a compound of $K_2O$ and $SiO_2$ in the ratio of 1:4, 1:5, 1:6, and 1:7, but is a convenient method of expressing the molecular composition of the mixture.

fully mixed on glazed paper and then returned to the original platinum crucible. As finely powdered silica tends to stick to all vessels with which it is in contact, this method keeps the silica loss at a minimum. The heating schedule followed was

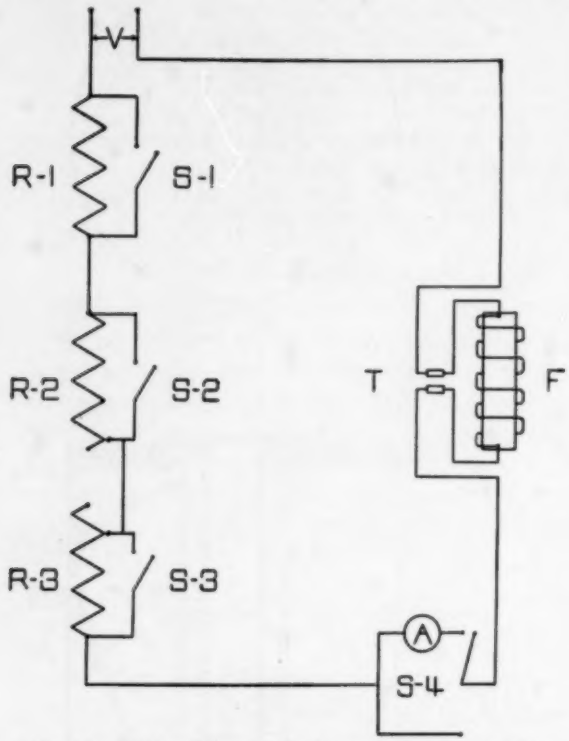


FIG. 2.—Wiring diagram: *A*, ammeter; *F*, furnace winding; *R*, rheostats; *S*-1, 2, 3, single-pole, single-throw shunting switches; *S*-4, single-pole, double-throw switch; *T*, 15 ampere fuses; and *V*, 110-volt a.c. current.

one designed to decrease the losses due to volatilization and mechanical ejection. The crucible containing the charge was heated gently over a Bunsen burner for two hours. It was next placed in a Hoskins furnace at a temperature of 800° to 900°C and kept there for twelve hours, after which it was transferred to the crystallizing furnace at a temperature of approximately 1000°C. The furnace temperature was then raised to 1400°C, and the charge was allowed to remain at least for five hours. The thoroughly fused glass was then cooled and placed over $P_2O_5$ in a desiccator. Despite this careful procedure, there was always a slight loss in weight. This loss was ascribed to the volatilization of the $K_2O$, because, according to Sosman,[9] the direct volatilization of silica at temperatures under 1600°C has not been proved. The charge was accordingly weighed, crushed, and corrected for this loss by adding an amount of potassium bicarbonate necessary to supply the $K_2O$ needed. Three fusions followed by fine crushings were necessary to obtain homogeneity.

The glasses in the ternary system, involving iron, were made by adding the necessary quantity of ferric oxide to the powdered binary glasses and fusing. After six crushings and fusions, the glasses were examined for homogeneity. This test consisted of an examination of some immersed grains under a petrographic microscope and the search for reddish-brown patches of undissolved ferric oxide. As long as these patches persist, it is necessary to re-fuse the glass until they disappear. In some cases this required but four fusions; all of the prepared glasses, however, were fused six times. The temperature of fusion varied, following in general the indicated curvature of the liquidus.

## V. Ferrous Oxide Content of Some of the Glasses

The dissociation of ferric oxide in alkali-silicate glasses has been discussed by Hostetter and Roberts,[10] who found the dissociation to be relatively

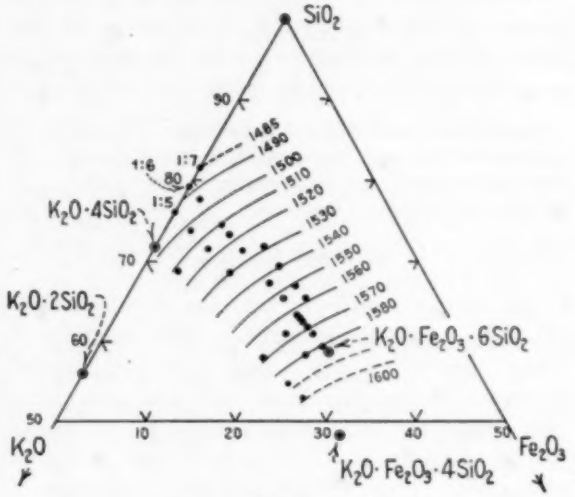


FIG. 3.

small, especially if the glasses were prepared below 1200°C. In the study of the system, $Na_2O$–

[9] R. B. Sosman, The Properties of Silica, p. 109. Chemical Catalog Co., New York, 1927.

[10] J. C. Hostetter and H. S. Roberts, "Dissociation of Ferric Oxide Dissolved in Glass and Its Relation to Color of Iron-Bearing Glasses," *Jour. Amer. Ceram. Soc.*, **4**, 927–38 (1921).

TABLE I

FERROUS OXIDE CONTENT OF SOME GLASSES ALONG THE $K_2O \cdot 6SiO_2$ SECTION

| Composition of original glass | | | | | | |
|---|---|---|---|---|---|---|
| $K_2O \cdot 6SiO_2$ (%) | $SiO_2$ (%) | $Fe_2O_3$ (%) | $K_2O$ (%) | FeO (%) | Temperature (°C) | $\frac{\%\ FeO}{\%\ total\ iron\ as\ Fe_2O_3} \times 100$ |
| 79 | 62.63 | 21.00 | 16.37 | 0.31 ± 0.03 | 928.4 | 1.48 |
| 78 | 61.84 | 22.00 | 16.16 | 0.29 ± 0.03 | 987.4 | 1.32 |
| 77 | 61.05 | 23.00 | 15.95 | 0.18 ± 0.01 | 1011.2 | 0.78 |
| 75 | 59.46 | 25.00 | 15.54 | 0.33 ± 0.01 | 1097.5 | 1.32 |

$Fe_2O_3$–$SiO_2$, Bowen, Schairer, and Willems[11] found that the dissociation reached a maximum of 1.09% FeO in a melt containing originally 35% $Fe_2O_3$ and held at 1175°C. A charge containing 26% $Fe_2O_3$ originally, after being held at 838°C, was found on analysis to contain 0.39% FeO.

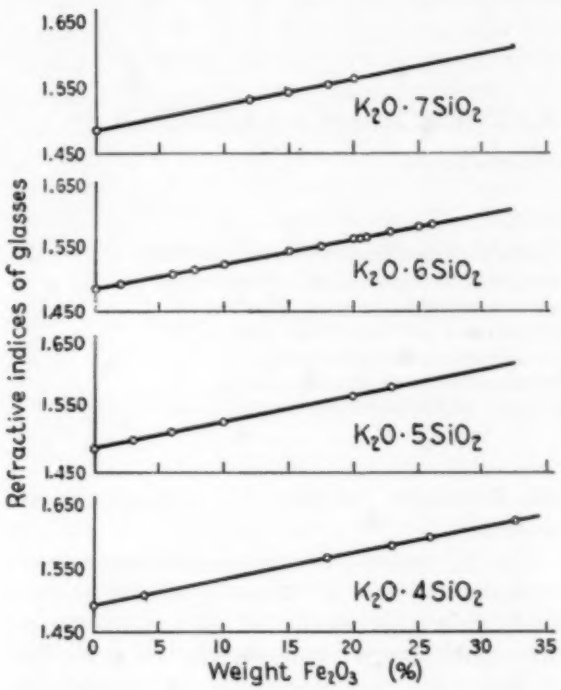


FIG. 4.

Several glasses along the $K_2O \cdot 6SiO_2$ section were analyzed to determine the FeO content at *the liquidus temperature*. Samples of one-half gram weight were wrapped in platinum foil and were held at approximately the liquidus temperature for that composition and for the same period of time as was necessary for equilibrium. These analyses were carried out according to methods described at length elsewhere[12] and will not be repeated here.

In Table I, the data indicate the extent of the dissociation in the potash glasses. It is to be noted that these values apply *only* to the temperatures given and can not be arbitrarily interpreted for any other temperature.

TABLE II

| Series No. | Composition by synthesis $K_2O$ (%) | $Fe_2O_3$ (%) | $SiO_2$ (%) | Index of refraction | Rough estimate of color |
|---|---|---|---|---|---|
| 400 | 28.17 | | 71.83 | 1.494 | Clear |
| 404 | 27.04 | 4.00 | 68.96 | 1.510 | Very light brown |
| 418 | 23.10 | 18.00 | 58.90 | 1.564 | Brown |
| 423 | 21.69 | 23.00 | 55.31 | 1.585 | Deep brown |
| 425 | 21.13 | 25.00 | 53.87 | 1.599 | " " |
| 432 | 19.06 | 32.32 | 48.62 | 1.621 | Very dark brown (almost black) |
| 500 | 23.88 | | 76.12 | 1.489 | Clear |
| 503 | 23.16 | 3.00 | 73.84 | 1.502 | Light yellow |
| 506 | 22.45 | 6.00 | 71.55 | 1.515 | Dark " |
| 510 | 21.49 | 10.00 | 68.51 | 1.528 | Yellow-brown |
| 520 | 19.10 | 20.00 | 60.90 | 1.566 | Brown |
| 523 | 18.39 | 23.00 | 58.61 | 1.578 | " |
| 600 | 20.72 | | 79.28 | 1.486 | Clear |
| 602 | 20.31 | 2.00 | 77.69 | 1.493 | Light yellow |
| 606 | 19.48 | 6.00 | 74.52 | 1.509 | Yellow |
| 607.5 | 19.17 | 7.50 | 73.33 | 1.513 | " |
| 610 | 18.65 | 10.00 | 71.35 | 1.524 | Light brown |
| 615 | 17.61 | 15.00 | 67.39 | 1.543 | " " |
| 617.5 | 17.09 | 17.50 | 65.41 | 1.552 | " " |
| 620 | 16.58 | 20.00 | 63.42 | 1.562 | Brown |
| 620.5 | 16.47 | 20.50 | 63.03 | 1.562 | " |
| 621 | 16.37 | 21.00 | 62.63 | 1.563 | " |
| 623 | 15.95 | 23.00 | 61.05 | 1.571 | " |
| 625 | 15.54 | 25.00 | 59.46 | 1.579 | Very dark brown |
| 626 | 15.33 | 26.00 | 58.67 | 1.582 | " " " (almost black) |
| 700 | 18.31 | | 81.69 | 1.483 | Clear |
| 712 | 16.11 | 12.00 | 71.89 | 1.528 | Light brown |
| 715 | 15.56 | 15.00 | 69.44 | 1.541 | " " |
| 718 | 15.01 | 18.00 | 66.99 | 1.551 | Brown |
| 720 | 14.64 | 20.00 | 65.36 | 1.559 | " |

These values are of the order of magnitude as found by previous investigators.

[11] N. L. Bowen, J. F. Schairer, and H. W. v. Willems, "Ternary System, $Na_2SiO_3$–$Fe_2O_3$–$SiO_2$," *Amer. Jour. Sci.*, [5] **20**, 405–55 (1930); p. 418; *Ceram. Abs.*, **11** [5] 382 (1932).

[12] (*a*) B. A. Soule, "Determination of Ferrous Iron in Silicate Rocks," *Jour. Amer. Chem. Soc.*, **50** [6] 1691–94 (1928); *Ceram. Abs.*, **8** [10] 769 (1929).
(*b*) N. L. Bowen and J. F. Schairer, "System FeO–$SiO_2$," *Amer. Jour. Sci.*, [5] **24**, 177–213 (1932); *Ceram. Abs.*, **12** [2] 83 (1933).

### VI. Refractive Indices of the Glasses

The refractive indices of the glasses were measured by the usual petrographic microscopic methods employing immersion liquids, the values of which were checked on an Abbé total reflectometer[13] immediately after use. The accuracy of the measurements is ± 0.002. The results of these measurements are listed in Table II. It should be pointed out that no intentional attempt was made to anneal the glasses. In Fig. 3, the results have been plotted on a ternary diagram and the isofracts (lines connecting glass compositions of equal refractive index) have been sketched in. The relation between the refractive index and the ferric oxide content of the glasses along the $K_2O \cdot 4SiO_2$–$Fe_2O_3$, $K_2O \cdot 5SiO_2$–$Fe_2O_3$, $K_2O \cdot 6SiO_2$–$Fe_2O_3$, and $K_2O \cdot 7SiO_2$–$Fe_2O_3$ sections is plotted in Fig. 4. Along these sections, the relation is apparently linear. From the partial data on the phase relations in the system $K_2O \cdot 4SiO_2$–$Fe_2O_3$–$SiO_2$, it can be said that the isofracts contain no breaks at the position of breaks on the liquidus curves.

[13] Using the light from a sodium flame.

**Acknowledgments**

The authors wish to thank J. F. Schairer of the Geophysical Laboratory for his kindness in helping them to initiate this investigation. The senior author carried out a portion of this work while a Fellow in the Mineralogical Laboratory at the University of Michigan and completed certain measurements at the Department of Ceramics in Rutgers University. The authors appreciate the financial assistance rendered by the University of Michigan Faculty Research Fund.

# IMPROVEMENT OF STIFF-MUD CLAYS THROUGH $p_H$ CONTROL*

By G. J. Barker and Emil Truog

Abstract

Clays, when given a correct alkali treatment, show a marked improvement in working qualities. They become more plastic, require less power to extrude the clay through the die, and, when dried, have greater strength and are less pervious to water. The tendency of clays to laminate is reduced. The fired ware is stronger and has a lower moisture absorption. Both acid and calcareous clays are susceptible to improvement by this process. The amount of reagents must be carefully controlled by $p_H$ measurement for best results. The method of testing for $p_H$ and the limits within which the two type clays must be held are described.

### I. Introduction

It has been definitely established by the writers in laboratory experiments that if the $p_H$ of clays is properly adjusted and controlled before forming into ware for structural clay products, marked improvements result in the physical properties of the clay and the structural ware made from the clay. For example, the plasticity of the clay is increased, a stronger and more pliable clay column is produced, less mixing water is required, less power is consumed in extruding the clay through the die, a sounder clay column is produced, and in some cases laminations in the clay structure are reduced or eliminated. The strength of the finished product, both compressive and transverse, is greatly increased, the moisture absorption is lowered, and the color is often more pronounced.

This $p_H$ control procedure for the improvement of heavy clayware is the result of eight years of study on a large number of clays. The present investigation began with the study of the mineralogical constituents of the clays and the base exchange properties of the colloidal fraction whose particles are too fine to be identified by ordinary methods. In the mineralogical examinations, the clay samples were centrifuged in nitrobenzene and symmetrical tetrabromoethane mixtures whose specific gravities ranged from 1.25 to 2.93. This centrifuging separated the various minerals into groups, according to their specific gravities. The segregated groups were weighed, and, by petrographic examination, a close estimate was made of the percentages of the various minerals present in each group. The identified mineral groups were potash feldspar and bauxite; plagioclase feldspar and calcite; mica and calcium-magnesium

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carbonate; and fluorite, chlorite, limonite, titanite, garnet, and zircon.

In addition to these mineral particles, the clays contain large amounts, as much as 50%, of colloidal material (less than 0.2$\mu$ dia.) which can not be identified by microscopic methods.

## II. Base Exchange of Colloidal Portions

It has now been definitely established that the substances causing base exchange in soils exist in the colloidal fraction, which consists of secondary minerals that have been developed by the processes of weathering. This discussion will be confined to a study of the inorganic material.

There is still some question regarding the nature of this base exchange material. It is agreed generally, however, that it contains silica and alumina, that it may also contain magnesia (which is not replaceable), and that several somewhat different compounds are involved. Earlier investigations at Wisconsin[1] give some evidence that the compounds usually involved have approximately the following empirical formula, depending on the nature of the base or the cation saturations ($Fe_2O_3$ may replace $Al_2O_3$):

$CaO \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O$ (exchange saturated with calcium).
$Na_2O \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O$ (exchange saturated with sodium).
$H_2O \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O$ (exchange saturated with hydrogen).

X-ray analysis indicates that the compounds are crystalline. The particles are often submicroscopic in size and are apparently seldom or never large enough for petrographic identification. Because of the thorough distribution of these compounds in the colloidal matter and over the surfaces of the mineral particles in soils and clays and because of the pronounced properties of flocculation or deflocculation which these compounds possess, they exercise a controlling influence on the flocculation or deflocculation of the whole mass of soil or clay. In other words, when the exchange compounds flocculate, the whole mass flocculates, and when the exchange compounds deflocculate, the whole mass deflocculates.

The properties of these compounds when saturated with calcium are greatly different than when saturated with sodium, especially as to ease of deflocculation. When saturated with calcium, the compounds deflocculate with difficulty, but flocculate or coagulate easily, thus conferring on the soil a granular and porous structure which is so essential for a high state of fertility. One of the benefits of liming acid soils is the attainment of a better physical condition through the replacement of the hydrogen in the exchange compounds with calcium. In acid soils, the exchange compounds are at least partially saturated with hydrogen.

## III. Effect of Clay Dispersion

When partly or wholly saturated with sodium, the exchange compounds deflocculate easily, especially if the $p_H$ falls within certain ranges, causing the soil to run or puddle easily if worked when too wet. On drying, the puddled soil becomes hard, compact, impervious, and hence infertile. This ease of puddling of clays, which is so undesirable in agriculture, is just what is desired in the manufacture of brick, tile, terra cotta, and other clay products. To produce clay brick and tile with a uniform, dense, impervious, and strong body, it is necessary that, in tempering and pugging, the compound granules become thoroughly broken down and the particles dispersed so that the whole mass becomes thoroughly puddled and uniform in texture. When the exchange compounds are saturated with calcium, as is the case in high lime clays, it is difficult to attain this thorough dispersion and puddling; when saturated largely with hydrogen, as is the case in acid clays, the dispersion and puddling are more easily attained; and when saturated at least partly with sodium and the $p_H$ controlled, as later indicated, dispersion and puddling are most easily and perfectly attained. This is illustrated by Fig. 1,

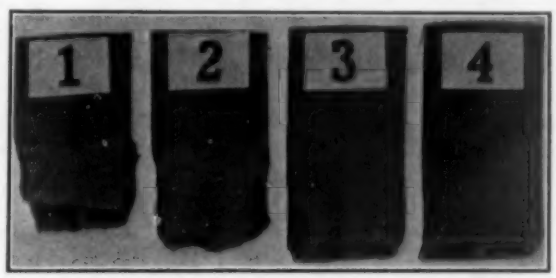


FIG. 1.—The effect of $p_H$ control on disintegration in water of dry tile made from a calcareous clay; (1) $p_H$ 8.1 (no treatment), (2) $p_H$ 8.75, (3) $p_H$ 9.2, and (4) $p_H$ 9.5.

[1] E. Truog and J. A. Chucka, "Origin, Nature, and Isolation of Inorganic Base Exchange Compound of Soils," *Jour. Amer. Soc. Agron.*, **22**, 553–57 (1930).

which shows the effect of $p_H$ control of a clay of high lime content on the tile produced.

The reactions involved when high lime clays and acid clays are treated with sodium carbonate may be represented, respectively, as follows:

$$CaO \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O + Na_2CO_3 \rightleftharpoons CaCO_3 + Na_2O \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O$$

$$H_2O \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O + Na_2CO_3 \rightleftharpoons H_2CO_3 + Na_2O \cdot 4Al_2O_3 \cdot 16SiO_2 \cdot xH_2O$$

These reactions proceed according to the law of mass action, and the extent of replacement depends upon the mass of sodium carbonate which is applied.

## IV. Exchangeable Bases in Clays

To compare a wide range of different type clays, thirty-four samples were tested to determine the exchangeable bases and the total base exchange capacities. The exchange capacities of these clays varied from 4.8 to 20.6 milliequivalents, as shown in the last column in Table I. As a general rule the clays with the highest exchange capacities carried small amounts of lime, and the high lime clays, basic in character, gave low exchange values.

## V. Control of $p_H$ Value Essential

Apparently there is little correlation between the amounts of exchangeable bases naturally present and the properties of these clays in relation to the manufacture of clay products. In column (2) of Table I, the $p_H$ values of the clays are shown and these values, when properly correlated, give more information about the properties of clay than any other single value. It has been found experimentally that if the $p_H$ value of any

TABLE I

| Clay No. | $p_H$ | $CO_2$ (m.e.) | Soluble calcium* (m.e.) | Soluble magnesium* (m.e.) | Total soluble calcium + magnesium (m.e.) | Soluble calcium + magnesium − $CO_2$ (m.e.) | Calcium magnesium (m.e.) ratio | Exchange capacity (m.e.) |
|---|---|---|---|---|---|---|---|---|
| I | 6.9 | 20 | 18.6 | 5.8 | 24.4 | 4.4 | 3.21 | 4.80 |
| B | 8.2 | 496 | 356.0 | 259.0 | 615.0 | 119.0 | 1.37 | 5.73 |
| A | 8.0 | 114 | 26.7 | 23.0 | 49.7 | −64.3 | 1.16 | 5.75 |
| F | 6.8 | 88 | 15.8 | 12.2 | 28.0 | −60.0 | 1.29 | 6.50 |
| H | 8.5 | 62 | 12.3 | 15.3 | 27.6 | −34.4 | 0.81 | 7.23 |
| 18 | 8.0 | 570 | 425.0 | 234.0 | 659.0 | 89.0 | 1.82 | 7.45 |
| 5 | 8.0 | 338 | 258.0 | 238.0 | 496.0 | 158.0 | 1.08 | 8.00 |
| 21 | 8.0 | 602 | 462.0 | 234.0 | 696.0 | 94.0 | 1.97 | 8.95 |
| 20 | 8.0 | 548 | 408.0 | 226.0 | 634.0 | 86.0 | 1.80 | 9.20 |
| 4 | 8.0 | 304 | 184.5 | 166.0 | 350.5 | 46.5 | 1.11 | 9.20 |
| 16 | 8.0 | 536 | 367.0 | 206.0 | 582.0 | 46.0 | 1.83 | 9.50 |
| C | 6.0 | 14 | 17.7 | 11.1 | 28.8 | 14.4 | 1.59 | 9.55 |
| G | 8.3 | 6 | 3.4 | 3.2 | 6.6 | 0.6 | 1.06 | 9.63 |
| 19 | 8.0 | 560 | 384.0 | 211.0 | 595.0 | 35.0 | 1.82 | 9.70 |
| X2 | 7.3 | 76 | 47.1 | 42.8 | 58.9 | 13.9 | 1.10 | 10.00 |
| E | 7.3 | 200 | 53.4 | 21.2 | 74.6 | −125.4 | 2.52 | 10.23 |
| 9 | 8.0 | 76 | 49.6 | 51.6 | 101.2 | 25.2 | 0.96 | 10.90 |
| X13 | 7.1 | 119 | 72.0 | 61.6 | 133.6 | 14.6 | 1.17 | 11.40 |
| 3 | 8.0 | 368 | 307.5 | 262.0 | 569.5 | 201.5 | 1.17 | 11.45 |
| 6 | 8.0 | 380 | 438.0 | 183.0 | 621.0 | 241.0 | 2.40 | 12.55 |
| 1 | 8.0 | 180 | 116.0 | 96.8 | 212.8 | 32.8 | 1.20 | 12.65 |
| X3 | 7.0 | 96 | 59.6 | 54.8 | 114.2 | 18.2 | 1.08 | 12.65 |
| X14 | 7.0 | 90 | 58.6 | 48.0 | 106.6 | 16.6 | 1.22 | 13.20 |
| X11 | 7.1 | 68 | 48.2 | 55.0 | 103.2 | 35.2 | 0.875 | 13.65 |
| X10 | 7.1 | 68 | 50.8 | 39.2 | 90.0 | 22.0 | 1.30 | 14.20 |
| 17 | 7.0 | 31 | 34.6 | 11.2 | 45.8 | 14.8 | 3.09 | 15.25 |
| X4 | 6.9 | 90 | 59.6 | 38.4 | 98.0 | 8.0 | 1.54 | 16.10 |
| X12 | 7.0 | 77 | 53.0 | 42.4 | 95.4 | 18.4 | 1.25 | 17.45 |
| D | 5.9 | 2 | 13.0 | 6.6 | 19.6 | 17.6 | 1.97 | 19.55 |
| X1 | 5.9 | 4 | 14.6 | 11.6 | 26.2 | 22.2 | 1.26 | 19.65 |
| 7 | 8.0 | 30 | 43.2 | 23.2 | 47.4 | 27.4 | 1.47 | 20.60 |

ACID CLAYS

| Clay No. | $p_H$ | Replaceable hydrogen (m.e.) | Exchange capacity (m.e.) |
|---|---|---|---|
| 11 | 5.7 | 3.7 | 15.5 |
| 10 | 6.0 | 2.3 | 15.9 |
| 2 | 6.3 | 1.8 | 17.2 |
| 8 | 5.2 | 7.8 | 19.6 |

* Soluble calcium and magnesium include that extracted by ammonium acetate solution of $p_H$ 5.5. Milliequivalents are expressed on the basis of 100 grams of material.

particular clay is controlled within certain definite limits, an optimum improvement of the physical character of the clay can be secured. In general, a treatment which produces a $p_H$ within the range of 6 to 8.5 in the case of acid clays and 7.3 to 10.5 in the case of nonacid clays is the most desirable. This does not mean that any acid clay can be so treated as to give a $p_H$ value any where within the range of 6 to 8.5 and have this result in the maximum improvement, but that, if it is so treated as to secure the maximum improvement, its $p_H$ will lie within the range of 6 to 8.5. Every clay which has been tested in this laboratory has responded to treatment and exhibited improved characteristics.

There are several cheap chemical compounds, such as sodium hydroxide or sodium carbonate, potassium hydroxide or potassium carbonate, ammonium carbonate, or hydroxide, which can be used to adjust the $p_H$ of clays.

## VI. Experiments Made

Sodium carbonate was selected because of its general cheapness and effectiveness. In the laboratory, various type clays were treated with varying amounts of sodium carbonate, and the effect of the addition agent upon the physical character of the clay and the products produced after forming and firing was studied. To compare results obtained between a treated and untreated clay, a small extrusion machine was built which would make small tile or brick specimens. With this machine (Fig. 2), it was possible to

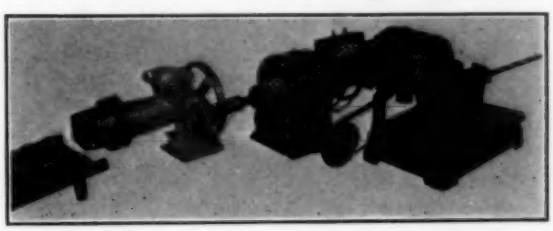

FIG. 2.—Small extrusion machine and setup designed for experimental purposes.

measure the power required to force the clay through the die, to study the structure of the ware for laminations and other defects, and to observe the general workability of the clay. It was observed early that the addition of small amounts of sodium carbonate had the effect of softening a given clay mass, of producing a better workability so that the clay slipped through the die with less pressure, and, in the finished ware, of producing a finer structure.

The procedure followed in the tests was to air-dry the clay and add to a weighed portion the desired amount of mixing water in which had been dissolved the amount of sodium carbonate required to give the desired percentage of this material to the mixture. The clay was pugged thoroughly and then extruded through the die in the form of a two-cell tile. As the column was extruded, the power required to operate the machine was read. The cut tile were immediately weighed and then dried on a steam rack, after which the loss in weight was calculated as the percentage of mixing water. This method was used because it was found that in mixing and pugging, evaporation and other losses occurred which made it difficult to control exactly the water content of the clay. When dry, thirty-five tile were placed in a gas-fired furnace and fired at a carefully controlled temperature. The firing time was approximately eight hours, and care was exercised to place the tile in the kiln in such a manner that minimum differences in temperature would occur. After cooling, the boiling test was applied to each piece, and the moisture absorption was determined. The tile were then broken, and the crushing strength was determined.

TABLE II

ACID CLAY

(Brick)

| $p_H$ of clay | Treatment ($Na_2CO_3$%) | Moisture absorption (%) | Compressive strength (lb. per sq. in.) | Strength increase (%) |
|---|---|---|---|---|
| 5.4 | None | 12.10 | 6357 | |
| 6.4 | 0.1 | 12.25 | 6857 | 7.85 |
| 7.4 | 0.2 | 11.35 | 7010 | 10.25 |
| 8.0 | 0.3 | 9.50 | 7765 | 22.10 |
| 8.5 | 0.4 | 11.98 | 7533 | 18.50 |

CALCAREOUS CLAY

(Tile)

| | | | | |
|---|---|---|---|---|
| 7.52 | None | 17.2 | 1230 | |
| 7.98 | 0.1 | 16.9 | 2080 | 69.1 |
| 8.20 | 0.2 | 15.2 | 2145 | 74.4 |
| 8.75 | 0.4 | 14.9 | 2230 | 81.3 |
| 9.20 | 0.6 | 13.8 | 2440 | 98.4 |

Table II gives the data on two clays tested, and the correlation of these results with observations made during the tests furnishes conclusive information.

The acid clay, $p_H$ 5.4, contained some free iron oxides and changed to a darker red color when its $p_H$ was raised. This was true both in the dried

and fired ware. This color change made it easy to distinguish visually between the treated and untreated clay. The treated clay became more plastic, required less mixing water, and passed through the die with a marked saving in power. The formed ware was much smoother in appearance and, after firing, produced a better looking piece of ware. Table II indicates that when the acid clay is treated to raise its $p_H$ to 8.0, there is an increase in compressive strength and a decrease in moisture absorption of the fired ware. For this clay, the optimum $p_H$ is 8.0, and if it is higher than this, the benefits imparted to the clay by the treatment are lessened; if the $p_H$ goes too high, all improvements may be destroyed.

The calcareous clay was benefited materially by treatment with sodium carbonate. This clay, before being treated, is plastic, has a firing temperature of about 2050°F, laminates badly, and after firing has a rather high moisture absorption. When this clay was given a treatment increasing its $p_H$ to 9.2, its plasticity was improved, the clay column was free from cracks, and the fired ware was stronger in compressive strength and lower in moisture absorption. This clay was fired at 2050°F, and when given the optimum treatment, the crushing strength was increased almost 100%. If high strength is not required, a lower firing temperature can be used for this clay when it is properly treated.

## VII. Lamination Is Reduced

Visual examination of the ware as it came from the mouth of the die showed that clays which laminate can sometimes be entirely cured of lamination by a slight adjustment of the $p_H$. Figures 3 and 4 show the laminations in an untreated clay and how these laminations were prevented by adjusting the $p_H$ of the clay from 7.8 to 8.5 by the addition of 0.1% of sodium carbonate. This is a remarkable improvement in the clay and naturally produces a ware of better quality.

## VIII. $p_H$ Control Required

During the investigation which has been outlined, the authors became convinced that the $p_H$ control process which has been described requires close control to develop the marked improvements in the physical properties of the clay, in forming the ware, and in the structural nature of the finished ware itself. Employment of the properly controlled $p_H$ process increases the plasticity of the clay, develops a stronger and more pliable clay column, requires less mixing water, and takes less power to extrude the clay through the die. Furthermore, the clay column is stronger, and laminations in the clay structure are reduced and in some cases eliminated. The fired ware also shows improvements. Compression and transverse strengths are increased materially, moisture absorption is lowered, and color is often more pronounced. These results can be

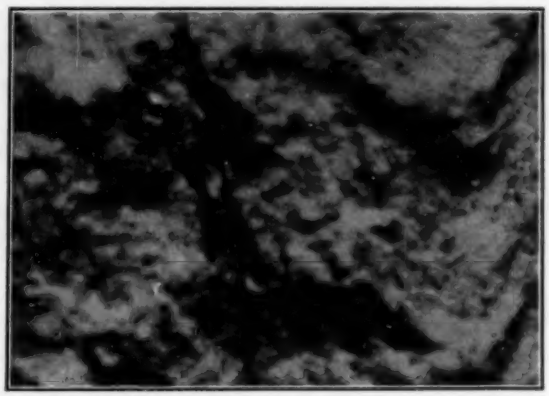

FIG. 3.—Laminated structure in clayware; no treatment; 5×.

obtained if the proper control of conditions in the clay are established during treatment. This control involves the application of some method of measuring the alkalinity or acidity of the treated clay.

The authors found early in the investigation that this $p_H$ control could not be secured by the addition of definite amounts of basic materials to the clays, but that the proper control could be exercised only by establishing definite acidity and alkalinity ranges for clays of different general nature within which the addition of the basic materials would give the most beneficial results. It was recognized that clays, generally high in calcium and iron, would contain varying constituents which would affect the additions made and the $p_H$ range which would be the most favorable. The problem was to determine these ranges for the different type clays, and then to adapt some means of measuring and controlling the necessary addition of basic materials.

Because certain constituents of various clays exert a buffer capacity to the action of basic materials, the necessary reaction range can not be attained through the addition of a definite weight

of basic material per ton of clay, based on the original $p_H$ of the clay. In view of this situation, the authors decided to measure the effect of adding known amounts of the basic materials to various clays in terms of hydrogen-ion concentration in the mass of the treated clay to find the optimum concentration or $p_H$. Because the hydrogen-ion concentration is a true measure of active acidity or alkalinity in a mass of clay (or any other test material), this seemed logical.

FIG. 4.—No laminations in ware; 0.1% sodium carbonate treatment; 50×.

Early experiments in this attempt indicated that colorimetric methods of determining the $p_H$ of clays were not well adapted for the purpose in hand. Hydrogen-ion electrometers were later used. One type with a ball electrode was found to be unsatisfactory. While this electrometer can be used satisfactorily in determinations involving liquid or thin suspensions of clay, it is not designed to handle stiff-mud specimens. The successful determination of hydrogen-ion concentration in stiff-clay samples is possible with an electrometer which possesses a spear-type electrode. This machine will work satisfactorily when either solutions or stiff muds are being tested and will give results that can be reproduced in successive tests.

## IX. Summary

Summarizing the results obtained from eight years of experimental work in the laboratory, it is indicated that most clays can be improved in physical properties by a treatment which adjusts the $p_H$ of the clay within certain ranges. The range for acid clays is from $p_H$ 6 to $p_H$ 8.5, and for the nonacid clays from $p_H$ 7.3 to $p_H$ 10.5. When clays are treated so as to have the correct $p_H$, the following improvements are obtained:

(1) The treated clay is more plastic than the nontreated clay.

(2) Less mixing water is usually required to give the desired plasticity.

(3) Less power is required to pass the clay through a die because it is more plastic.

(4) The physical structure of the clay column is improved, and with clays which have a tendency to laminate, proper treatment will often eliminate the laminations.

(5) The clayware is more perfectly formed with less cracking and corner defects.

(6) Dried, treated ware is less pervious to water and often can be placed in water for a period of ten minutes without disintegrating.

(7) The firing temperature is usually lowered because the clay has a closer body.

(8) The compressive and transverse strengths of the fired ware are greater.

(9) Moisture absorption is lower, especially when laminations are reduced.

(10) The color of the clayware is usually improved. The reds are made more brilliant, and some light cream, high calcium clays will be made to fire red if there is some iron in the clay.

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# NOTES ON THE USE OF PYROPHYLLITE AS AN ELECTRICAL INSULATOR*

By Frank J. Stevens

Abstract

Results of a few tests made on pyrophyllite bodies are recorded for the benefit of others interested in the application of that material to their use. Physical and electrical data are tabulated.

## I. Introduction

While pyrophyllite deposits in North Carolina have been known for more than one hundred years,[1] this mineral, $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$, has not been applied in ceramics in general or to electrical insulators in particular until recently. Production of the mineral was of no importance until after 1928. In view of the extent of the deposits of pyrophyllite, it is well known that much investigation has been carried on to find uses and a market for it.

As its physical properties resemble those of ground talc, $3MgO \cdot 4SiO_2 \cdot 2H_2O$, its early application was as a substitute for ground talc in roofing, textiles, rubber, and toilet articles. Recently, however, pyrophyllite has been used as a ceramic body ingredient in varying percentages in wall tile and tableware and as an addition to electrical porcelains.

Commercially, little has been done to date to exploit the material by the company making these tests; nevertheless, it is worth recording that only in the past few weeks commercial quantities of star-shaped resistor coil forms were made up from extruded sections for one of the large electrical companies for a special application. Reports indicate that these pieces have proved highly satisfactory for that particular use.

By comparing data in the following tables with other data on steatite and porcelain insulating materials, pyrophyllite may be used where the sterling qualities of pure steatite are not strictly needed. Being sufficient in many applications where a large element of the cost is in the raw material, pyrophyllite will have an economic advantage over the more scarce and expensive materials because of its low first cost.

## II. Properties of Pyrophyllite

On a weight basis, pyrophyllite with a composition of $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$ is $Al_2O_3$ 28.3%, $SiO_2$ 66.7%, and $H_2O$ 5.0%. At present, commercial ground pyrophyllite of different grades and fineness may be obtained from a number of North Carolina mills; note that analysis No. 1 almost coincides with the theoretical analysis.

Table I

Typical Analyses of North Carolina Pyrophyllite

| | No. 1 | No. 2 | No. 3 | No. 4 | No. 5 |
|---|---|---|---|---|---|
| $SiO_2$ | 64.86 | 70.15 | 64.26 | 75.3 | 69.62 |
| $Al_2O_3$ | 28.14 | 23.84 | 30.28 | 20.5 | 24.52 |
| $Fe_2O_3$ | 0.15 | 0.07 | Trace | 0.1 | 0.32 |
| $TiO_2$ | N.d.* | 0.15 | N.d.* | N.d.* | N.d.* |
| CaO | 0.68 | 0.06 | Nil | 0.2 | 0.28 |
| MgO | N.d.* | 0.02 | 0.30 | N.d.* | N.d.* |
| $Na_2O$ | 0.38 | 0.20 | N.d.* | 0.3 | 0.40 |
| $K_2O$ | 0.01 | 1.54 | N.d.* | | 0.48 |
| $H_2O$ | 5.73 | 4.00 | 6.60 | 3.6 | 4.10 |

* N.d. = not determined.

It is evident from this analysis that some properties may be accentuated by selection of the raw material.

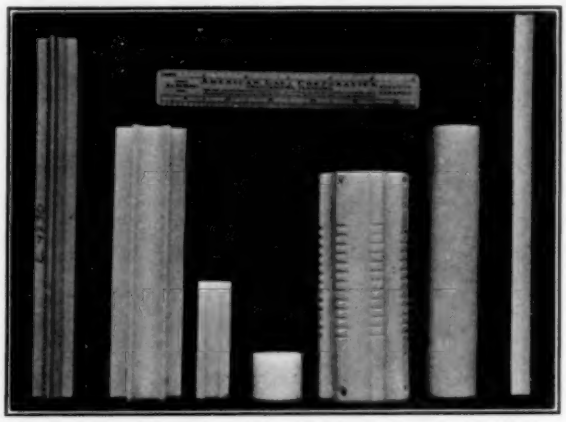

Fig. 1.—Extruded sections of pyrophyllite.

In these experiments, a decision was made to start with 100% pyrophyllite and to work toward smaller percentages as dictated by the results obtained. Accordingly, sufficient organic binder

* Presented at the Fortieth Annual Meeting, American Ceramic Society, New Orleans, La., March 29, 1938 (White Wares Division). Received March 12, 1938.

[1] W. A. Milliken, "Pyrophyllite Developments in N. C.," *Ceram. Age*, **17** [1] 18–19 (1938).

was added to pure pyrophyllite to extrude it, and subsequent bodies were tried out, made up with a plastic flux, and fired at cone 14. Tests were on bodies made up from analysis No. 2 (Table I).

Pyrophyllite fires paper-white, usually with a slight gloss on the surface. As firing is advanced to the point where blistering occurs, the gloss becomes more pronounced. In breaking, the fracture is rough, entirely unlike a glassy porcelain.

## III. Mechanical Test

Mechanical tests were made according to A.S.T.M. specifications.

TABLE II

| Laboratory body No. | Green O.D. | Fired O.D. | Diametrical shrinkage (%) | Load | Modulus of rupture (lb./sq. in.) |
|---|---|---|---|---|---|
| H-145 | 1.260 | 1.148 | | 740 | 6250 |
| | | 1.147 | | 795 | 6750 |
| | | 1.148 | | 925 | 7800 |
| | | 1.147 | | 780 | 6600 |
| | | 1.149 | | 700 | 5900 |
| | | 1.146 | | 680 | 5750 |
| Av. | | 1.148 | 9.6 | | 6510 |
| 247 | 1.260 | 1.178 | | 1105 | 8650 |
| | | 1.178 | | 1240 | 9700 |
| | | 1.177 | | 1470 | 11500 |
| | | 1.177 | | 1105 | 8650 |
| | | 1.178 | | 1470 | 11500 |
| | | 1.176 | | 1195 | 9400 |
| Av. | | 1.177 | 7.0 | | 9900 |
| 248 | 1.260 | 1.154 | | 1365 | 11,300 |
| | | 1.157 | | 1315 | 10,840 |
| | | 1.158 | | 1290 | 10,600 |
| | | 1.157 | | 1555 | 12,810 |
| | | 1.158 | | 1470 | 12,080 |
| | | 1.157 | | 1230 | 10,160 |
| Av. | | 1.157 | 8.9 | | 11,300 |

## IV. Dielectric Strength Tests

Tests were made on disks having a diameter of 1.110 inches. Pieces were tested under oil, and the voltage was raised at approximately 500 volts per second until puncture occurred.

TABLE III

| Body No. | Thickness of plate (in.) | Puncture voltage | Volts/mil. | Av. volts/mil. |
|---|---|---|---|---|
| H-145 | 0.130 | 24,000 | 185 | |
| | .126 | 24,000 | 190 | |
| | .129 | 28,500 | 220 | 198 |
| | .037 | 7,500 | 200 | |
| | .043 | 12,500 | 290 | |
| | .039 | 13,500 | 345 | 278 |
| 247 | .130 | 20,000 | 154 | |
| | .130 | 25,000 | 194 | |
| | .128 | 25,500 | 200 | 183 |
| | .040 | 7,000 | 175 | |
| | .039 | 7,000 | 180 | |
| | .041 | 7,000 | 171 | 174 |
| 248 | .130 | 20,000 | 154 | |
| | .128 | 25,000 | 195 | |
| | .128 | 25,500 | 200 | 183 |
| | .035 | 9,000 | 257 | |
| | .035 | 9,500 | 272 | |
| | .034 | 9,000 | 264 | 262 |

## V. Dielectric Constant

TABLE IV

| Body No. | KC | Power factor (%) | Dielectric constant | Loss factor (%) |
|---|---|---|---|---|
| H-145 | 100 | 0.9 | 5.6 | 5.08 |
| | 1500 | 0.8 | | 4.52 |
| 247 | 100 | 3.2 | 5.5 | 17.60 |
| | 1500 | 0.8 | | 4.40 |
| 248 | 100 | 0.8 | 5.5 | 4.40 |
| | 1500 | 0.7 | | 3.85 |

## VI. Specific Gravity and Porosity

TABLE V

| Body No. | Pyrophyllite content (%) | Open pore specific gravity | Porosity (%) |
|---|---|---|---|
| H-145 | 100 | 2.37 | 2.96 |
| 247 | 96 | 2.32 | 1.71 |
| 248 | 94 | 2.39 | 0.46 |

## VII. Conclusions

The tests above show that pyrophyllite bodies compare favorably with porcelain in mechanical and electrical characteristics and may be used in applications where high puncture values or zero porosity are not prerequisites. Pyrophyllite is superior to porcelain in high-frequency applications but it is inferior to steatite.

The results obtained indicate the desirability of continuing the investigation of this promising material.

### Acknowledgment

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AMERICAN LAVA CORPORATION
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# SCHEDULE OF MEETINGS

## THE AMERICAN CERAMIC SOCIETY

I. FORTY-FIRST ANNUAL MEETING, STEVENS HOTEL, CHICAGO, ILL., APRIL 16–22, 1939

II. GENERAL AUTUMN MEETING, SAN FRANCISCO, CALIF., SEPTEMBER, 1939

III. ART DIVISION
- (1) Dearborn Inn, Dearborn, Mich., October 24–25, 1938
- (2) Seventh National Ceramic Exhibition, Syracuse, N. Y., October 27–November 21, 1938
- (3) Carnegie Museum, Pittsburgh, Pa., January, 1939

IV. WHITE WARES AND MATERIALS AND EQUIPMENT DIVISIONS
Bedford Springs Hotel, Bedford, Pa., September 15–17, 1938

V. GLASS DIVISION
Chamberlain Hotel, Old Point Comfort, Va., September 9–12, 1938

VI. REFRACTORIES DIVISION
Bedford Springs Hotel, Bedford, Pa., September 2–3, 1938

## PORCELAIN ENAMEL INSTITUTE FORUM

Third Annual Meeting, Urbana, Ill., October 12–14, 1938

## INTERNATIONAL GLASS CONGRESS

Berlin and Munich, Germany, July 6–15, 1939

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**2525 North High Street, Columbus, Ohio**

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### Abrasives

**Cement to replace glue in polishing wheels.** Anon. *Mill & Factory*, **20** [3] 106 (1937).—A material is described which replaces glue as a binding agent in grinding wheels. D.A.B.

**Emery of Samos.** J. de Lapparent. *Mineralog. & Petrog. Mitt.*, **49**, 1–30 (1937).—The emery of Samos is a pisolitic diaspore rock which contains little corundum. The rock was originally a diasporitic bauxite. The diaspore was recrystallized by a shearing stress, resulting in a reduction of part of the $Fe_2O_3$ to magnetite and the formation of chloritoid. See "Stages—," *Ceram. Abs.*, **14** [11] 291 (1935). H.I.

**Grinding chart.** Carboloy Co. *Mill & Factory*, **20** [4] 9 (1937).—An 18- x 12-in. chart gives recommendations on grinding wheels. See *Ceram. Abs.*, **17** [2] 51 (1938). D.A.B.

**Grinding milling cutters tipped with cemented carbides.** H. Ernst and M. Kronenberg. *Can. Machinery*, **48**, 78–81, 134 (June, 1937).—A technical procedure is given for grinding cutting tools tipped with cemented carbide, emphasis being placed on the kind of wheels, size, speed of grinding, kind of abrasives, diamond wheels, angle of grinding, and general technique. D.A.B.

**Industrial diamond.** Anon. *Bull. Imperial Inst.*, **34** [4] 458–63 (1936).—Diamond is a mineral of growing industrial importance. Because of its hardness, its principal use is for abrasive purposes. Carbonado (carbon or black diamond), ballas, and bort are the varieties used. The source of supplies and the uses are described. A.P.S.

BOOKLET

**Handy grind catalogue.** Dumore Co. Reviewed in *Mill & Factory*, **19** [4] 11 (1936).—Wheels and abrasive bands are discussed. D.A.B.

PATENTS

**Abrading machine.** P. H. Hutchinson (General Motors Corp.). U. S. 2,122,942, July 5, 1938 (Dec. 10, 1935).

**Abrading machine.** Vassaf Kadri (Nouri Rejeb and Mary Bagdadi). U. S. 2,120,252, June 14, 1938 (Sept. 15, 1936). A housing, a roller rotatably carried by the housing and provided with a substantially V-shaped peripheral groove and a second peripheral groove having substantially paralleling side walls, the grooves being spaced apart and extending longitudinally of the roller.

**Abrasive article.** J. N. Kuzmick and L. S. Hilton (Raybestos-Manhattan, Inc.). U. S. 2,122,691, July 5, 1938 (April 28, 1936). A solid and compressible abrasive article comprises abrasive particles bonded with a copolymer of chloroprene and a synthetic resin, the synthetic resin acting to controllably reduce the elongation or stretch of the chloroprene.

**Abrasive sleeves and rolls.** D. E. Mulholland. Brit. 487,133, June 29, 1938 (Dec. 30, 1937).

**Apparatus for cutting hard substances.** A. L. Ball (Carborundum Co.). U. S. 2,123,705, July 12, 1938 (Oct. 4, 1934). Apparatus for grinding very hard substances and for distributing the wear of a grinding wheel with substantial uniformity over the major portion of the working surface of the wheel.

**Boron carbide manufacture.** Raymond R. Ridgway (Norton Co.). Can. 374,116, May 31, 1938 (June 10, 1937; in U. S., June 10, 1936). G.M.H.

**Buffing wheel.** F. E. Hendrickson (Murray Ireland). U. S. 2,122,609, July 5, 1938 (Oct. 12, 1936).

**Composite abrasive wheel.** Baalis Sanford (Norton Co.). U. S. 2,121,746, June 21, 1938 (Jan. 12, 1937). The method of making a composite abrasive wheel having a central support and an abrasive rim comprises the steps of premolding a heat-settable material selected from the class consisting of an unconverted resinoid and a vulcanizable rubber compound and thereby forming a plastic supporting body having substantially its final volume, separately molding a mixture of abrasive grains and a bond of the type selected for the support to form an abrasive rim, heat setting the rim to its final nonplastic condition, thereafter assembling the central support and rim in a pressure mold with a heat-settable cement there-

between, pressing the wheel parts without distorting the rim and causing a plastic flow of the support into a firm union with the rim, and heating the wheel to set the unconverted material of the support and cement into a final hard condition.

**Container for polishing-wheel composition.** V. J. TWYNING (J. C. Miller Co.). U. S. 2,122,665, July 5, 1938 (Nov. 22, 1937).

**Cutting-off wheel.** D. E. WEBSTER (Norton Co.). U. S. 2,121,751, June 21, 1938 (March 30, 1937). A cutting-off wheel comprises a body of abrasive grains bonded by hard vulcanized rubber and having a thickness not greater than 0.025 in., wherein the abrasive and rubber on each side of the wheel are substantially completely coated with a thin film of an infusible insoluble resinoid which strengthens the wheel and provides nonabrasive sides.

**Electric-furnace structure for making abrasive metal carbides.** R. R. RIDGWAY (Norton Co.). U. S. 2,123,158, July 5, 1938 (Nov. 21, 1935).

**Flexible coated abrasive product.** H. O. ANDERSON (Norton Co.). U. S. 2,123,581, July 12, 1938 (Aug. 15, 1936).

**Grinding or abrading machines.** JONES & LAMSON MACHINE CO. Brit. 486,981, June 29, 1938 (Feb. 24, 1936). NORTON CO. Brit. 487,327, June 29, 1938 (Dec. 20, 1935).

**Grinding machine.** ARTHUR SCRIVENER. U. S. 2,122,184, June 28, 1938 (Jan. 15, 1937). A grinding machine for the correction of screw threads and other helical surfaces.

**Grinding machine work loading and driving mechanism.** R. A. COLE (Norton Co.). U. S. 2,121,730, June 21, 1938 (Nov. 29, 1937).

**Grinding wheel.** J. F. FISCHER (Abrasive Co.). U. S. 2,121,656, June 21, 1938 (March 12, 1938). A molded article comprises an annular body member and an annular reinforcing element embedded and bonded in each side face of the annular body member immediately adjacent and surrounding the central opening therein, the reinforcing elements each including a web portion disposed flush in a side face of the body member, an edge flange lining at least a portion of the central opening of the body member, and a portion projecting into the body member substantially parallel to its axis of rotation.

**Grinding wheel.** NORTON GRINDING WHEEL CO., LTD. Brit. 487,287, June 29, 1938 (July 22, 1936).

**Lapping machine.** W. F. EGGER (A. P. Schraner Co.). U. S. 2,121,025, June 21, 1938 (May 1, 1936).

**Machine for grinding clutch facings, etc.** H. B. ELDRIDGE AND C. E. KLEIN. U. S. 2,122,978, July 5, 1938 (April 18, 1936).

**Making boron carbide.** NORTON GRINDING WHEEL CO., LTD. Brit. 486,817, June 22, 1938 (June 10, 1936).

**Polishing apparatus.** A. E. HAMILTON. U. S. 2,123,171, July 12, 1938 (Nov. 14, 1936).

**Rubbing brick.** W. L. BURGER. U. S. 2,120,483, June 14, 1938 (June 26, 1936).

## Art and Archeology

**Addition to the collection of Greek and Roman art.** G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **33** [1] 27 (1938).—Three terra cotta vases, seven glass vases, and a bead necklace have been given to the Museum by Mrs. George D. Pratt. The vases are a fine lekythos of the late proto-Corinthian style (second half of the 7th Century B.C.), a Roman green-glazed pottery cup of the late Republic and early Empire, and an alabastrum with heraldic lions and a bird of the early Corinthian style, about 625 to 600 B.C. A.A.A.

**Antiques exposition in New York.** HELEN COMSTOCK. *Connoisseur*, **101** [442] 329 (1938).—The exhibit includes an unusual pair of Sèvres urns with views of New York, which are familiar on Staffordshire ware but unique on Sèvres and probably a special commission. The scenes are finely drawn and colored; the neck and base are firegilt, and the floral design on the base is etched. M.E.P.

**Art in a Pennsylvania-German community.** WILLIAM SWALLOW. *Design*, **40** [1] 4–5 (1938).—S. describes the well-organized art department of the consolidated South Whitehall Schools where the children are given an opportunity to express themselves and to release their creative energy. Clay is believed to be as important as paint and pencil for expression, and a well-equipped ceramics room, including 36 small modeling wheels, clay bins, a closet for damp work, and an electric kiln, is a part of the department. Much work with masks and modeling, in connection with dramatics, is also done in this department. M.E.P.

**Bavarian enamels of the 17th Century.** CHARLES R. BEARD. *Connoisseur*, **97** [417] 267–71 (1936).—By descriptions and comparison of technique, B. endeavors to establish the origin of these enamels which are used to decorate small objects of domestic use such as candlesticks, small boxes, buttons, knife handles, and jewelry. The matrix on which the enamel is fired is generally of copper, sometimes of low-grade silver, and in one instance of gold; it is cast with cloisons outlining conventional patterns of flowers, leaves, and arabesques in the manner of Michel le Blon and the South German craftsmen of the second half of the 16th Century. The enamels are often left with the fire glaze on them and range in color through white, black, dark blue, light blue, and, rarely, red, green, and yellow. M.E.P.

**Bohemian hollow glass.** A. DORN. *Deut. Glaserztg.*, **49**, 286 (1938).—D. gives examples of cut, engraved, and sandblasted vases. A gold-yellow crystal glass was used. See *Ceram. Abs.*, **17** [7] 242 (1938). E.P.

**Canadian Guild of Potters.** NUNZIA D'ANGELO. *Jour. Can. Ceram. Soc.*, **7**, 13–14 (1938).—The growth of the Potters' Guild in Toronto is outlined. The object of the Guild is to further the interest in handicraft pottery by obtaining suitable clays and glazes, arranging facilities for firing, holding exhibitions, etc. The Guild now has a membership of about fifty. The programs are educational in character, and an effort is made to develop an interest in a Canadian artistic style. The sale of pottery is aided by the Canadian Handicraft Guild which has established several stores. J.G.P.

**Ceramics in the Federal Art Project of Ohio.** CHARLOTTE GOWING COOPER. *Design*, **40** [1] 10 (1938).—Considerable recognition has been given to the ceramic sculpture done under the supervision of Edris Eckhardt of the Cleveland unit. C. describes the technical processes of molding, firing, and glazing the pieces sculptured by the artists. As these ceramics are planned for the public libraries and schools, the subjects are confined to children's stories and classics. M.E.P.

**Cup by Tleson.** G. M. A. RICHTER. *Bull. Metropolitan Mus. Art*, **33** [2] 52–54 (1938).—A cup by the Tleson painter has just been reconstructed from fragments purchased ten years ago and from recently acquired additional fragments. It is a lip cup of the "little-master" type and may be dated in the third quarter of the 6th Century B.C. It is the fourth signed "little-master" cup in the Museum's collection. A.A.A.

**Early American blown glass.** MARSHALL DAVIDSON. *Bull. Metropolitan Mus. Art*, **32** [12] 287–88 (1937).—Two contrasting examples of Early American blown glass have recently been acquired. A tall chalice of brilliant flint or lead glass, attributed to Sandwich, Mass., is a graceful shape, blown very thin, depending on the limitations of the tools used for its design. A two-handled greenish glass vase of an earlier date is blown to a more sturdy shape. Its short cylindrical neck and low crimped foot is a more familiar style than the Sandwich vase. In the thick sections of the vase the color is darker green, conforming to the so-called South Jersey style. A.A.A.

**Early development of chemical industry in Bristol.** STANLEY ROBSON. *Chem. & Ind.*, **57** [9] 200–203 (1938).—The origin of the glass and pottery industries goes into the remote past, the early history being largely unknown. Bristol was prominent in the manufacture of all kinds of glassware during the 18th Century. Bottles were originally blown into stone molds, sectioned metal molds being later introduced by Messrs. Ricketts. The earliest recorded glasshouse in Bristol was in 1651, and the last works closed down about 1922. The remains of a Roman pottery furnace were discovered at Shepton Mallet. A complete change in design of pottery drinking vessels was occasioned by the introduction of tea and coffee in late Stuart times. English potters soon started to make the necessary teapots, cups, and saucers. The first factories for delftware in Bristol were at Brislington. The earliest fragment known is dated 1652. The large circular dishes known as "blue dash chargers" were made in Bristol. One of the factories at Temple Back produced painted and printed earthenware, under the management of the Pountneys, up to 1906. The production of porcelain in Bristol, though lasting for less than 50 years, had a profound effect upon English ceramics. Lowdin's famous factory and the Bristol china manufactory are briefly discussed. G.R.S.

**Early Italian majolica.** C. LOUISE AVERY. *Bull. Metropolitan Mus. Art*, **33** [1] 10–13 (1938).—The Schiff collection of early Italian majolica has been lent to the Museum. It is noted for its many rare pieces of 14th and 15th Century Italian majolica. The collection also includes a great deal of richly colored ware of the high Renaissance. The term "majolica" was first used to designate Spanish luster pottery brought into Italy by way of Majorca but is now used with special reference to the tin-enameled pottery made in Italy since the 14th Century. It also describes tin-enameled pottery following the Italian technique made at other places. Orvieto ware, green Florentine ware, and ware from other parts of Tuscany, blue impasto ware, graffito ware, and a soft porcelain plate such as was made under the patronage of the Medici in Florence are among the collection. A.A.A.

**Elliot collection.** *Connoisseur*, **101** [442] 321 (1938).—Full-page color illustration of a Bow figure of a shepherd boy after Giovanni Bologna (British Museum), a Longton Hall figure of a goatherd, and a Chelsea Red Anchor mark figure of a Chinaman (both Victoria and Albert Museum) which are part of the Wallace Elliot Collection. See "Victoria—," *Ceram. Abs.*, **17** [7] 243 (1938). M.E.P.

**English delftware.** C. L. A. *Bull. Metropolitan Mus. Art*, **32** [11] 269–70 (1937).—Recent accessions are a hand warmer in the shape of a book, probably the work of a Bristol potter, and two large dishes belonging to the group described as "blue dash chargers"; the designation was given to them because they were bordered by a series of short slanting blue lines and made as display pieces. The dish illustrated has a stylized symbolic picture of Queen Anne. It was probably made at Bristol or at Brislington in the early 18th Century. See "English—," *Ceram. Abs.*, **16** [7] 195 (1937). A.A.A.

**English pottery.** JOSEPH DOWNS. *Bull. Metropolitan Mus. Art*, **32** [10, Sect. 1] 224–26 (1937).—An English delft wine bottle (dated 1644) and jug (dated 1647), both examples of Lambeth delft pottery, have been given by Mrs. Paul Moore. They are characteristically English in design and decoration, although there was a great deal of majolica then made that was similar to Faenza and Urbino ware. A warm pinkish lavender appears where the tin glaze thins, showing the hard buff-colored clay of the body. A.A.A.

**Iranian Expedition (1936). Excavations at Nishapur.** CHARLES K. WILKINSON. *Bull. Metropolitan Mus. Art*, **32** [10, Sect. 2] 3–22 (1937).—The Iranian Expedition in the spring of 1936 continued the excavation begun in Nishapur in 1935. The ceramics found establish the importance of Nishapur as one of the great artistic centers of the Islamic world and are invaluable for the study of the history of ceramic art in the Near East. By the aid of coins found, hitherto unknown types of pottery may be assigned to the late 8th Century or the beginning of the 9th Century. Most of the pottery bowls are of fine reddish clay with well-made bases and thin walls. Glazes are usually transparent and colorless over a colored slip. In the cellar of Sabz Pushan was a fine piece decorated with graffito work, a white slip with scratched design strengthened by manganese brown. It is also decorated with splashes of yellow, green, and brown. The rim is thicker than the wall owing to its being inverted after it was dipped in glaze. Other fine bowls, vases, sweetmeat dishes, fragments of glazed tile, and pottery have been found, making it possible to date several types of early Islamic pottery. A.A.A.

**Modern Italian glass.** C. L. A. *Bull. Metropolitan Mus. Art*, **32** [11] 268–69 (1937).—Seven examples of contemporary Italian glass made by the Venezia-Murano Co. include two figures, one a lively squirming fish and the other a whimsical version of the Lion of Saint Mark, a large vase, two bottles, a covered box from a toilet set, and a low bowl. A.A.A.

**Principles and methods of etching and embossing.** BRUNO SCHWEIG. *Glass*, **15** [4] 143; [5] 184 (1938).—For either clear or deep etching, a solution of concentrated HF diluted with 2 to 10 parts of water is recommended. To dissolve the fluorides formed during the process, $H_2SO_4$ is added for lime glasses and $HNO_3$ for lead glasses. The more diluted the acid, the brighter and clearer will be the glass. Glasses roughened by grinding may be polished by immersion in a dilute HF solution. This is especially suitable for lead glasses which are thus given a brilliance and polish obtainable in no other way. In producing a white frosted surface, the greater the number and the smaller the crystals, the denser and whiter will be the surface. Barium glasses produce a coarse mat, while lead glasses are the finest. Oxides of Ca, Zn, and Al give intermediate results. Various compositions of etching solutions, including colored etching, are given. S. describes a method for protecting frosted glasses from the effects of weather with a protective layer of an aluminum salt such as sulfate, tartrate, or oxalate. B.C.R.

**Sung fresco and ten Chinese porcelains.** ALAN PRIEST. *Bull. Metropolitan Mus. Art*, **33** [4] 97–100 (1938).—A recent gift includes ten large porcelains. The most interesting is a blue and white jar made in the Hsüan Tê period (1426–1435). The other pieces belong to the K'ang Hsi period (1662–1722). A.A.A.

**Swedish glass.** J. POLÍVKA. *Tchéco Verre*, **5**, 77–79 (1938); see "Glass—," *Ceram. Abs.*, **17** [7] 247–48 (1938). E.P.

**We work glass.** A. DORN. *Tchéco Verre*, **5**, 26–28 (1938).—D. describes work done at the German State Technical School for the Glass Industry at Steinschönau and Haida. Examples of cut, engraved, and gilded glass are illustrated. See "Experimental—," *Ceram. Abs.*, **17** [8] 273 (1938). E.P.

BOOK

**Pottery of the Ancients.** HELEN STILES. E. P. Dutton & Co., Inc., New York. 128 pp., 82 illustrations, 5 drawings. Price $2.50. S. presents an elementary record of ancient ceramic art from 3000 B.C. to the 17th Century. The text is chronologically and geographically compiled for purposes of general information. It is a sketchy story of the beginning of the potter's art according to archeological findings and study, mainly in the better-known prolific pottery-producing centers of the Egyptians, Mohammedans, Greeks, Chinese, and Japanese. In a brief introduction, Charles M. Harder makes the following statements: "There have been potters in every land and in every age. Each has taken the earth around him and shaped it into beautiful things; and yet the work of each is unlike all the rest. Why?" S. attempts to answer this question by explaining the factors influencing the lives of the people of these different countries. Three hundred examples illustrate the types of pottery under discussion. These are mostly from the collections of the

Metropolitan Museum of Art and the Pennsylvania University Museum. The end papers and line drawings are by Marion Downer. While the text gives only a surface treatment of such an inclusive and fascinating subject, it brings together, in comparatively few pages, the essential facts that most students of ceramic history will find both entertaining and helpful. KENNETH E. SMITH

PATENTS

**Clock with front of ceramic, vitreous, etc., material.** GEB. JUNGHANS AKT.-GES. Brit. 487,315, June 29, 1938 (Jan. 15, 1937).

**Designs for:**

**Ashtray.** G. A. MENGLE (Brockway Glass Co., Inc.). U. S. 110,097, June 14, 1938 (April 9, 1938).

**Bottle.** GEORGE SMITH, JR. (Olean Glass Co.). U. S. 110,115, June 14, 1938 (April 19, 1938). N. F. STEUER (Owens-Illinois Pacific Coast Co.). U. S. 110,504, July 12, 1938 (May 25, 1938).

**Glass.** E. W. FUERST (Libbey Glass Co.). U. S. 110,483 and 110,484, July 12, 1938 (June 1, 1938).

**Glass bottle.** J. H. KEENS. Can. 11,994, May 9, 1938. G.M.H.

**Goblet.** A. J. CUNNINGHAM. U. S. 110,272 and 110,273, June 28, 1938 (April 28, 1938). R. R. KOSTELLOW (United States Glass Co.). U. S. 110,112, June 14, 1938 (Feb. 16, 1938).

**Medicine bottle.** C. D'O. P. JACKSON (T. & H. Smith, Ltd.). U. S. 110,180, June 21, 1938 (Jan. 17, 1938).

**Plate.** A. J. KOCH (Onondaga Pottery Co.). U. S. 110,359, July 5, 1938 (Dec. 1, 1937).

**Teapot.** LEONARD BRINDLEY (Hall China Co.). U. S. 110,170, June 21, 1938 (Feb. 24, 1938).

**Tray.** M. H. CONNOR (Owens-Illinois Can Co.). U. S. 110,207, June 21, 1938 (Nov. 16, 1936).

**Tumbler.** B. D. FUERST (Libbey Glass Co.). U. S. 110,278, 110,279, and 110,281, June 28, 1938 (Nov. 30, 1937). U. S. 110,280, June 28, 1938 (Dec. 3, 1937).

**Device for measuring color and light densities.** ROBERT MACKAY. U. S. 2,120,499, June 14, 1938 (March 25, 1935).

**Flower exhibiting device of glass.** ROBERT W. SIMPSON. Can. 374,652, June 21, 1938 (Oct. 22, 1936; in U. S., Oct. 22, 1935). G.M.H.

## Cements

**Calcium sulfate plasters.** J. S. DUNN. *Chem. & Ind.*, **57** [7] 144–48 (1938).—Three distinct crystalline modifications of calcium sulfate known are gypsum, $CaSO_4 \cdot 2H_2O$, monoclinic; anhydrite, $CaSO_4$, rhombic; and subhydrate, $3CaSO_4 \cdot 2\text{-}0H_2O$, orthorhombic. The first two are well known, and there is general agreement about their properties and crystal form. The third is still being investigated and discussed. Setting reactions are controlled by the rates of (1) solution of the unstable hydrate which depends upon the area of surface presented, (2) diffusion of Ca and $SO_4$ ions from the unstable hydrate, and (3) precipitation on the stable hydrate which should also depend upon the area of surface presented. Studies of the effect of retarders and accelerators are reported. G.R.S.

**Clinker quality and liter weight.** G. MUSSGNUG. *Zement*, **26** [41] 671–76 (1937).—Liter weight is not sufficient to determine quality because irregularities in chemical composition are not evidenced. The apparent gravity shows accurately the degree of firing. The true specific weight is still better, the influence of pore volume being eliminated. The importance of firing on the practical properties of cement is undisputed. The liter-weight method of firing control is a recent advancement. F.E.V.

**Coefficients of friction between rubber tires and concrete road surfaces.** E. M. FLEMING. *Proc. Highway Research Board*, **14** [Part I] 214–16 (1934). H.M.R.

**Effect of calcium chloride on Portland cements and concretes.** P. RAPP. *Proc. Highway Research Board*, **14** [Part I] 341–81 (1934); see *Ceram. Abs.*, **15** [10] 293 (1936). H.M.R.

**Ferrari cements.** F. FERRARI. *Zement*, **27** [1] 1–6 (1938).—The brownmillerite or Ferrari cements contain alumina and iron oxide in equivalent quantities. If lime saturation is reached, the mineral composition is simple, alite and brownmillerite; with lower lime content, dicalcium silicate is also present. Ferrari cements are said to have good workability with little water, regular setting, quick hardening, high binding power, evolution of limited heat, small shrinkage, good elasticity during hardening, excellent resistivity against chemical attack, and durability. Ferrari cements with a low silica modulus are economically fired. The clinker is hard but brittle. The absence of tricalcium aluminate is a sound basis for pozzuolanic or slag cements. 33 references. F.E.V.

**Heats of hydration and transition of calcium sulfate.** EDWIN S. NEWMAN AND LANSING S. WELLS. *Jour. Research Nat. Bur. Standards*, **20** [6] 825–36 (1938); R.P. 1107. Price 5¢. The heats of solution, at 25°C in 2.09 molal HCl, of gypsum, hemihydrate, natural anhydrite, and anhydrous $CaSO_4$, prepared by heating gypsum at various temperatures, were determined. From these values, the heats evolved in the hydration to gypsum of hemihydrate and of anhydrite prepared at 1000°C were calculated to be 4100 ± 30 and 3990 ± 20 cal./mole, respectively. The heat evolved in the hydration to gypsum of soluble anhydrite prepared by dehydrating gypsum at 75°C is not less than 6990 cal./mole. In the course of this work, X-ray and microscopic studies gave no indication of the existence of more than two forms of anhydrous calcium sulfate. Soluble anhydrite and a modification formed rapidly at high temperatures, the latter being identical with natural anhydrite. The heat evolved in the transition of soluble anhydrite to natural anhydrite is not less than 3000 cal./mole. R.A.H.

**Investigation on curing of concrete pavement slabs.** ANON. *Proc. Highway Research Board*, **13** [Part II] 7–96 (1933). H.M.R.

**Investigation of $CuSO_4 \cdot 5D_2O$ and $CaSO_4 \cdot 2D_2O$ crystals.** P. P. BUDNIKOV AND L. S. PALATNIK. *Zhur. Fiz. Khim.*, **10**, 719–24 (1937).—An X-ray investigation was made of $CuSO_4 \cdot 5D_2O$ and $CaSO_4 \cdot 2D_2O$ crystals, prepared by dehydrating $CuSO_4 \cdot 5H_2O$ and $CaSO_4 \cdot 2H_2O$ (C.P.) under vacuum at a corresponding temperature and by a subsequent treatment with heavy water ($D_2O$). The introduction of $D_2O$ instead of ordinary crystallization water ($H_2O$) changes the structure of these crystals. According to the dehydration curves $CaSO_4 \cdot 2D_2O$ and $CaSO_4 \cdot 2H_2O$, it can be concluded that the bond of crystallization of $D_2O$ in the gypsum lattice is less stable than in the case of ordinary $H_2O$. P.B. & E.S.

**Preparation of tricalcium aluminate hexahydrate.** A. TRAVERS AND H. ZAHABI. *Compt. Rend.*, **205** [26] 1407–1409 (1937).—Starting from a solution of calcium phenate with an excess of solid pure lime and some potassium aluminate, the reaction $3(C_6H_5O)_2Ca + Al_2O_3K_2O + 8H_2O = Al_2O_3 \cdot 3CaO \cdot 6H_2O + 2C_6H_5OK + 4C_6H_5OH$ takes place, and the salt is precipitated. The procedure is described in detail. M.H.

**Problems in the study of hydraulic cements.** F. M. LEA. *Chem. & Ind.*, **57** [4] 71–75 (1938).—The nature of reactions when cement and water are mixed was investigated by means of phase-equilibrium studies and by direct examination of the cement hydration product. Physical properties of set cements are affected by changes in moisture content and volume change on wetting and drying. See *Ceram. Abs.*, **15** [1] 6 (1936). G.R.S.

**Properties of clinkers rich in manganese and sulfur.** G. MUSSGNUG. *Zement*, **26** [50] 809–12 (1937); see *Ceram. Abs.*, **17** [4] 132 (1938). F.E.V.

**Properties of tricalcium aluminate hexahydrate and an-**

**hydrous tricalcium aluminate.** A. TRAVERS AND H. ZAHABI. *Compt. Rend.*, **206** [1] 55–57 (1938).—The authors describe investigations on the constitution of these salts. Their properties and method of preparation as given by other authors are, in general, confirmed, except that no decomposition takes place between 700° and 1100°C for $Al_2O_3 \cdot 3Ca \cdot 6H_2O$ (for a new method of preparing this salt see "Preparation—," p. 298). M.H.

**Quantitative determination of clinker minerals with the polarization microscope.** O. E. RADCZEWSKI AND H. E. SCHWIETE. *Zement*, **27** [17] 246–57; [18] 275–80; [19] 287–91 (1938).—The method of determination with the integration apparatus of Leitz or Fuess (sigma) is described. The limit of error is 2 to 6% according to conditions. The pores and the dicalcium silicate are irregularly scattered. Sodium light is the most favorable. A clinker rich in tricalcium silicate was investigated at different grades of firing. Liter weight and pore volume (measured by the microscope) are related. In a highly fused clinker, the pore volume is smaller and the tricalcium silicate content higher. The computation of minerals by the Lea and Bogue method does not agree with the optical determination. The content in $3CaO \cdot SiO_3$ is higher than calculated, particularly in high-fired clinkers. Granulometry, optical determination, and liter weight enable a good control of clinker. F.E.V.

**Report of Subcommittee on Maintenance of Concrete Pavement Cracks and Expansion Joints.** W. H. ROOT. *Proc. Highway Research Board*, **13** [Part I] 339–47 (1933). H.M.R.

PATENTS

**Improving gypsum.** BERLINER GIPSWERKE L. MUNDT. Ger. 657,251, Feb. 10, 1938 (Oct. 8, 1935); VI/80*b*. 6.05. A small amount of urea is added to the gypsum. D.A.B.

**Plant for sintering cement.** FRIED. KRUPP GRUSONWERK, AKT.-GES. Ger. 657,252, Feb. 10, 1938 (March 9, 1933); V/80*c*. 11. The plant consists of a blast grate (air being admitted from below) charged with material and burning material, a rotary kiln for sintering material, and a degasing unit (steam or air heater). D.A.B.

## Enamel

**A.-c. electro-pickling, a better method of pickling.** ALLAN B. DOVE. *Enamelist*, **15** [4] 21–31 (1938).—Tests made on the Ferrolite electro-pickling process are reported. If steam costs are disregarded, the electrolytic operation can still be used on a par with other normal types of pickling; at identical cost, therefore, there would still be the advantages of low iron loss, high-speed pickling, and excellent quality of surface. The results obtained can be greatly improved upon by the use of rubber- and brick-lined steel tubs. E.J.V.

**Age-old porcelain enamel finds new machine uses.** R. M. KING. *Machine Design Mag.*; reprinted in *Enamelist*, **15** [3] 41–45 (1937).—As porcelain enamel will resist both corrosion and abrasion, it is an ideal finish for metal machine parts. Because of its hard, enduring, nonporous surface, its resistance to corrosion, its transparency if desired, and its availability in colors, porcelain is finding applications in many different types of machines, *e.g.*, food weighing scales, Diesel engine exhaust pipes and mufflers, oil burners, corn feeding trough in the Tuc corn-husking machine, automobile manifolds, and in lining chemical equipment and milk truck tanks. Illustrated. E.J.V.

**Aspects of enameling in England.** S. W. VICKERY. *Jour. Can. Ceram. Soc.*, **7**, 65–70 (1938).—The first commercial enameling of cast iron commenced in England about 1850 and was carried on in the Midland area. The enameling of sheet iron articles followed and the enamel was generally applied by dipping. At the beginning of the 20th Century the application of enamels widened and the technique of enameling has steadily improved. The use of lead in enamels is forbidden in England, and this fact has given great impetus to the development of the technique of leadless enameling. All the cast iron used for enameling is cupola melted. It is the general practice to anneal all castings prior to enameling. In blasting, the use of flint is prohibited owing to the very heavy insurance protection against silicosis; therefore, steel grit is used. There is a strong tendency toward the substitution of sheet-iron parts for cast iron whenever practicable. For pickling, hydrochloric acid which costs less and pickles faster is used instead of sulfuric acid. The milling methods are substantially the same as in America. Enameling furnaces of the electric type are few, owing to the high cost of electricity. Coal-fired muffle furnaces predominate, but there are many oil-fired furnaces. J.G.P.

**Blasting or cleaning castings for enameling.** AUSTIN KELLY. *Jour. Can. Ceram. Soc.*, **7**, 54–55 (1938).—K. reviews the advancement of abrasive cleaning of castings in relation to the older methods. J.G.P.

**Drawing compounds: their composition and suitability for handling work that is to be porcelain enameled.** D. J. BENOLIEL. *Enamelist*, **15** [3] 7–8 (1937).—Most of the drawing compounds offered to the trade fall into two distinct classes: pigmented and unpigmented materials. Today, for the most part, nonpigmented products are the only ones offered to press shops for handling work before porcelain enameling. These products are usually oleic acid (red oil) soap, degras (wool oil) soap, or tallow soap mixed with water and free fat to make an emulsion. Polymerized fatty waxes properly mixed with certain mineral oils and then made soluble by the use of sulfonated oil soap seem to give highly successful results. This type of product will handle more difficult draws than the ordinary type offered on the market, will leave a film on the work that is a very effective protection against rust over a long period of time, and is just as easily removed from the work six months after drawing as when the work comes from the press. E.J.V.

**Enamel thickness gage.** S. H. BASTOW AND R. H. WHILLOCK. *Jour. Soc. Chem. Ind.* [London], **56**, 403–405 (Oct., 1937).—Diagrams and photographs are given, together with a description of the construction and operation of an apparatus of great accuracy. G.R.S.

**Endless-flow process for frit manufacture.** FERRO ENAMEL CORP. *Metal Cleaning & Finishing*, **10** [6] 444–46 (1938).—To make possible the production of porcelain enamel frit by the endless-flow process, Ferro built a mammoth new storage and mixing building, an intricate conveyer system, four patented continuous smelters, and a large finished storage warehouse for storing the finished frit. A detailed description of the operation of the process is given. Illustrated. E.J.V.

**English Parkinson stove.** ANON. *Emaillerie*, **6** [3] 24–25 (1938).—This type of stove is made of enameled sheet-iron panels on a cast iron structure. Photographs of the panel setting are shown. M.D.

**Factors important in producing one cover coat enamelware.** J. E. HANSEN AND G. H. MCINTYRE. *Jour. Can. Ceram. Soc.*, **7**, 55–58 (1938).—While one cover coat ware should be cheaper to produce than ware with two coats, it is generally agreed that the average shop will produce a better quality of ware in two cover coats of white enamel. In the authors' opinion "one coat white" (over ground coat) can be produced successfully only by the proper combination and functioning of various factors, including the enameling iron or steel, pickling, ground coat and cover coat enamels used, the application and firing, workmanship, handling, design of parts, and the type of furnace used. Base metal, enamels, design, equipment, hazards, color variation, and one cover coat hollow ware are discussed. No one cover coat project can be made successful by mere decision from "the front office" to run one cover coat work. It is probable that more, or at least closer, supervision will be called

for and more control of application and processing will undoubtedly be required. These various factors, and perhaps others, must be properly coördinated, the workmen trained, and the whole shop, including the inspection and sales department, must be made "one coat minded" before the program can be a success. After that, as one prominent enameler has stated, the production of one cover coat whiteware merely resolves itself into a problem of efficient enameling technique. J.G.P.

**Ferro demonstrates method for producing flat porcelain enameled sheets.** ANON. *Enamelist*, **15** [3] 23–25 (1937).—The sheets were first fired on points in the regular way in the ground coat and first white fire and were then fired on a special fixture which gave them a uniform concave bow across the width in the finish white fire. When the edges of the sheets were pulled down against a firm flat background, the sheets assumed a flat position virtually free from waviness. E.J.V.

**Forming of sheet-iron parts to be enameled.** L. B. HART. *Emaillerie*, **6** [3] 11–23; [4] 11–19 (1938).—H. reviews the fabrication of sheet-iron parts and gives recommendations for the selection and properties of sheet iron. Methods of shearing, blanking, and forming are described, and suitable locations for beads, flanges, or embossing are suggested. The type of furnace and the firing equipment affect the possible warping of parts. Annealing relieves the strain set up by forming or drawing operations. Drawing compounds must fit in with the cleaning process used. Parts are assembled before enameling either by gas or electric arc welding. Pieces should be folded to the proper angle and constructed from metal of the same thickness. Before dipping, all parts should be carefully inspected. As a rule, metal finishing should be avoided as it is extremely expensive; dinging and hammering are the best methods. Repairs, even though not always successful, should be made on faulty parts. M.D.

**Future of porcelain enameled iron as a building material.** PAUL BLACKBURN. *Jour. Can. Ceram. Soc.*, **7**, 49–54 (1938).—B. outlines the progress that has been made in expanding the market for porcelain enameled iron and points out some of the logical directions in which further growth may be expected. The use of porcelain enameled iron as an architectural material has grown in the United States from practically nothing in 1929 to an estimated 5 million dollars in 1937. Enameled iron is durable, but the impelling motive for the use of enameled iron on buildings today is the knowledge of its excellent properties as a medium for showmanship and advertising. Examples of the use of enameled iron for architectural purposes, in illuminated displays, as a decorative medium, and for the interior of homes are given. A careful research will reveal many items of home construction to which the corrosion resistance, structural strength, permanence, sanitation, and cleansability of enameled iron will make valuable contributions. An example is a chimney and flue lining of enameled iron which prevents destruction of mortar from corrosive gases and from the more corrosive condensation products of combustion. In the meantime, the all-enameled steel house offers the enameling industry its greatest challenge. J.G.P.

**Glassteel diffuser for mercury lighting.** ANON. *Mill & Factory*, **20** [4] 160 (1937).—A mercury lighting lamp using a white porcelain enamel reflector for diffusing light is described. D.A.B.

**Ground coat enamel suspension improvement.** RAY G. HARNER. *Enamelist*, **15** [3] 4–6 (1937).—In a system of continuously circulating, screening, and removing magnetic particles in sheet-iron ground coat slip, H. has installed a dip tank having a sloping bottom which permits the enamel to drain to the center of the tank. An outlet at this point connects with a pump which continuously draws the enamel slip from the tank and forces it to a point above the tank where it is discharged onto a screen. From the screen, the enamel slip flows through a magnetic separator and back to the dip tank. This system keeps the enamel clean and in good suspension without losing production time, lowers the clay content required, and improves draining qualities. Illustrated. E.J.V.

**Methods for setting up enameled sheet-iron panels.** ANON. *Emaillerie*, **6** [3] 7–9 (1938).—At the Ferro Enamel Corp., Oakland, enameled panels are fastened onto fiber or wood by molding strips nailed or screwed to the wall, gripping the panel on the edge of the lining. See *Ceram. Abs.*, **17** [2] 57 (1938). M.D.

**Mill additions.** ANON. *Emaillerie*, **6** [2] 13–22 (1938).—Careful attention must be given to milling and to the selection of suitable products to be used as mill additions. The action and properties of clay are given and special reference is made to the general features and specification of a good clay such as Valendar clay; it must develop good film strength in the dry coat of enamel. Clay as satisfactory as that from Valendar is obtained by mixing very fine opacifying clay with close-grained china clay. The difficulties to be encountered when using some types of clay, *e.g.*, fishscaling, etc., are given, together with their causes. Nonopacifying clays are exclusively used for dark colors and bright colors. Bentonite has a high setting power and gives a greater resistance to dry enamel coat, but not more than 0.250 kg. bentonite per 100 kg. should be added. All clays contain impurities, such as sand, mica, organic substances, etc., which spoil the enamel finish; several methods for purifying clay are recommended. When drying clay, a temperature not above 65°C must be used to keep the set-up power of clay. See *Ceram. Abs.*, **16** [8] 237 (1937). M.D.

**Modern kitchen.** ANON. *Emaillerie*, **6** [4] 9 (1938).—A modern kitchen displayed at the Housekeeping Exhibition held in Paris in February is described. Porcelain enamel stresses the cleanliness and attractiveness of the furniture. For paneling the walls, light-green porcelain enameled sheet-iron panels were used; all cupboards were cream colored. Illustrated. M.D.

**Power distribution for wiring enameling plant.** W. WENDELKIN. *Mill & Factory*, **20** [6] 65–68, 150 (1937).—The part that electricity plays in the manufacture of enameled wire is technically described. Electrical heating units (because of no flame) were installed in the heating chambers for firing the enamel on the wire. Temperature control can be kept within 5° by using better heat insulation. Illumination is provided in the plant by glassteel equipment (mercury lamps using enameled reflectors for diffusing light). D.A.B.

**Resistance of enamel to acid under high pressure.** K. P. AZAROV AND V. I. SAVCHENKO. *Céram., Verrerie, Email.*, **6** [2] 41–51 (1938).—The following facts were determined: (1) the corrosion of enamel grains changes little with decrease in size of the enamel granules; (2) enamel grains treated with sulfuric acid were more corroded than those treated with distilled water; corrosion is three times more effective with a 1.5% sulfuric acid solution, while with a 5% solution it is only four times more effective; (3) a further concentration of the acid solution has little effect under ordinary pressure; (4) at high pressure, up to 5 atm., corrosion greatly increases; (5) the resistance of enamels to acids under ordinary pressure differs from the resistance to acids at high pressure; (6) enamels of the first series, with an average boric anhydride content (6.6%) and a low silica content (63.7%), have the lowest index of corrosion with variable pressure, while enamels without boric anhydride have the highest index of corrosion; (7) increase of the alumina content of the enamel increases its resistance; (8) the lengthening of the duration of the treatment with a 1.5% sulfuric acid solution increases corrosion. M.V.C.

**Trocadero Theater.** ANON. *Emaillerie*, **6** [2] 7–11 (1938).—Enamel was used for decorating the newest and largest Paris theater. From the point of view of acoustics the use of enamel paneling is quite satisfactory. Photographs of the stage and decorations are given. M.D.

**Use of Setit to improve the workability and aging characteristics of a sheet-iron ground coat.** C. H. COMMONS, JR. *Jour. Can. Ceram. Soc.*, **7**, 59–61 (1938).—Setit is a

colloidal synthetic inorganic compound which acts as a buffering agent. It is supplied in powder form for use as a mill addition and is applicable for use in suspending enamels, glazes, and other water suspensions. In spite of the control now exercised, many plant conditions, frit properties, or water and weather conditions are such that the enamels age too rapidly to be satisfactorily workable. It is under these conditions that Setit should prove an aid to the enameler by removing the objectionable electrolytes from solution by either chemical reaction or absorption of the offending ions. C. summarizes some of the laboratory work dealing with this phase of the problem. J.G.P.

BULLETINS

**Stabilization of the reflectance and color of recoat enamels.** B. J. Sweo and M. J. Bahnsen. *Ferro Enamel Corp. Tech. Bull.*, No. 2, 19 pp. (July 5, 1938).—A substantially white enamel to be used for recoat purposes must possess the same degree of selectivity and a reflectivity approximately the same as the reflectance of the original enamel coating. The coefficient of scatter should preferably be high in order to obtain maximum covering power with minimum thickness of coating. Through consideration of the fundamental relationship between reflectance and thickness of material as expressed by Kubelka and Munk and later applied to measurements of opacity by Judd, Harrison, and Sweo (*Jour. Amer. Ceram. Soc.*, **21** [1] 16–23 (1938)), the authors were able to develop such a recoat enamel. This stabilizing enamel provides a means whereby recoated ware closely matches the original coating in color and reflectance. The experimental procedures and the industrial applications are discussed. 9 figures. F.J.Z.

**Heat transfer of porcelain enamel metals and other materials.** J. C. Bell. *Ferro Enamel Corp. Tech. Bull.*, No. 1, 28 pp. (June 1,1938).—B. compares the heat transferance of raw, painted, galvanized, and enameled irons, Monel metal, copper, aluminum, Allegheny metal, and Stainless steel. In the transfer of radiant heat in an insulated box, B. found that metals with a porcelain enamel finish are more efficient than bare iron or aluminum painted, galvanized, or chromium-plated iron. Porcelain enameled iron is more efficient in transferring heat than the polished metals. Over an open burner with a medium gas flame, porcelain enameled hollow ware is 14 to 19% more efficient than aluminum in relation to the time and fuel required to boil a given amount of water, and an aluminum pan with a rough bottom is slightly more efficient than one with a polished bottom. Over a high gas flame which does not impinge on the bottom of the pan, an aluminum pan is just as efficient as a porcelain enameled pan in transferring heat. Over an electric hot plate, porcelain enameled hollow ware is approximately 55% more efficient than aluminum in relation to the time and fuel required to boil a given amount of water, and an aluminum pan with a rough bottom is 25% more efficient than one with a polished bottom. The apparatus used is described. 13 graphs. F.J.Z.

PATENTS

**Bathtub.** J. A. Callahan (Briggs Mfg. Co.). U. S. 2,122,245, June 28, 1938 (Nov. 27, 1935; renewed Jan. 21, 1938).

**Making sinks.** Jacques Stanitz (Mullins Mfg. Corp.). U. S. 2,121,672, June 21, 1938 (June 29, 1936).

**Manufacture of colorless enamel, glazes, and glass.** Alfred Thürmer. Ger. 658,422, March 17, 1938 (March 26, 1935); VI/48*c*. 2.01. Colorless enamel, glazes, and glass are made by adding a mixture (0.2 to 6.0%) of alkali fluorides (NaF) and alkali meta-antimonates to the usual raw materials. D.A.B.

**Rustless iron.** W. B. Arness (Rustless Iron and Steel Corp.). U. S. 2,121,001, June 21, 1938 (July 26, 1935). In a composition of matter, a corrosion-resistant alloy iron of good ductility and weldability is unsubstantially hardenable by heat treatment, the alloy iron analyzing approximately 9 to 13 chromium, 0.005 to 0.035 nitrogen, 0.02 to 0.07% carbon, and the remainder consisting of iron.

**Sheet metal bathtub.** H. G. Coordes (Briggs Mfg. Co.). U. S. 2,122,247, June 28, 1938 (Jan. 7, 1936).

**Vitreous enameled products.** Monsanto Chemical Co. Brit. 486,280, June 15, 1938 (Oct. 5, 1936).

## Glass

**Adherence of aluminium to glass and its technical applications.** Bernard Long. *Jour. Soc. Glass Tech.*, **21** [88] 428–35 (1937).—Under certain conditions, glass surfaces are readily metallized by spraying with aluminium. The metal coating is tenaciously held by the glass. Preferably, glass to be metallized should be toughened to resist the chilling action of the blast from the spraying gun. The reflection power of aluminium-coated glass enables it to be used in adverse weathering conditions for mirrors at cross roads and for pavement lights. Hollow glass brick coated on the inside with aluminium greatly reduce the radiation losses obtained with the untreated brick. Aluminium resistances on glass, in the form of strips sprayed in a zigzag manner, make efficient glass radiators; floor blocks, coated with aluminium and forming a continuous electrical connection, enable heated floors to be used in offices and other rooms, the power expended being approximately 1200 watts/8 sq. m. to maintain a floor temperature of 30°. 15 figures. See "Use—," *Ceram. Abs.*, **17** [1] 15 (1938). G.R.S.

**Annealing leers.** C. J. Peddle. *Jour. Soc. Glass Tech.*, **21** [84] 177–86 (1937). G.R.S.

**Apparatus for the examination of cords, inhomogeneities, and surface unevenness in glassware.** E. Seddon. *Jour. Soc. Glass Tech.*, **21** [85] 281–84 (1937).—S. describes the detection of defects within the body and on the surface of glassware by a contrasting field method. Photographic examples of the visible effects produced by cords, stones, seeds, and surface unevenness are shown. 14 figures. G.R.S.

**Applications of glycerine.** Georgia Leffingwell and Milton A. Lesser. *Chem. Industries*, **42** [4] 395–98 (1938).—New uses of glycerine were determined by a search of the patent literature. L. describes the bonding of laminated safety glass by glycerine-phthalate resins which are made by combining glycerine, phthalic anhydride, and casein. Many other uses are also given. P.G.H.

**Bursting pressure test on glass bottles.** Arnold Cousen. *Jour. Soc. Glass Tech.*, **21** [84] 187–95 (1937).—Rapid or so-called snap bursting pressure tests are affected by the rate of pressure increase as well as by the method of support of the bottle, results tending to favor the smaller bottle. Sustained pressures of any desired amount up to about 700 lb./sq. in. can be easily and accurately applied by means of an apparatus designed by F. W. Preston (*Ceram. Abs.*, **14** [2] 45 (1935)). This instrument can be used either for dead-line testing or for a check on a more rapid snap test machine. Results from the sustained pressure tests decrease with increasing time of application of the pressure, the effect of fatigue being clearly shown. By means of the Preston machine the higher values for bursting pressure obtained in snap tests from bottles annealed in open leers as compared with those annealed in muffle leers are confirmed in cases where the pressure is applied for definite periods of time. G.R.S.

**Calculation of the physical properties of glass: III, Index of refraction.** P. Gilard and L. Dubrul. *Jour. Soc. Glass Tech.*, **21** [88] 476–88 (1937).—The method formerly proposed by the authors is used for the calculation of the refractive index of glass of various compositions. All published experimental data have been correlated, with a fair accuracy, by the formula $n_d = \Sigma ax + bx^2$.

Equations are given for the partial refractions of the various oxides. 14 figures. See *Ceram. Abs.*, **13** [9] 232 (1934). G.R.S.

**Changes of glass surfaces by grinding and polishing.** H. M. BRANDT. *Glastech. Ber.*, **16**, 123–31 (1938).—The test samples were prepared from four glasses of varying hardness by carefully polishing the back sides to avoid any errors during microscopic examination. Four grades of emery were used for the grinding. The samples were examined at intervals during the grinding and polishing by transmitted and reflected light to note changes in the character of the surface. During grinding, the glass is fractured, and some troughs are formed which are removed only by polishing. Some of these troughs have nearly vertical sides as shown by the slowness with which they are removed. The abrasive clings to uneven places and makes further working more difficult. By using an oil immersion lens and a liquid of the same index of refraction as glass, the process of polishing was followed by counting rouge particles clinging to the glass at various time intervals. The number of particles per sq. mm. plotted logarithmically against time gave a slightly S-shaped curve (little change in 4 min., a more rapid drop in number of particles from 4 to 10 min., and insignificant changes after 25 min.). A thorough search for evidence of occlusion of rouge in the glass as a result of surface flow was fruitless, although the nature of the surface pits was ideal for such an occurrence if flow was involved in polishing. No indications of flow around the edges of the pits was noted. Polishing, therefore, is a continuation of grinding and removal of glass. The samples were studied for light diffusion using a photometer. Plotting light intensity against angle of scattering showed a decrease in scattering with increasing wave-length. J.F.H.

**Constant temperature and humidity chamber for use in researches on the properties of glasses.** E. SEDDON. *Jour. Soc. Glass Tech.*, **21** [86] 350–55 (1937).—S. gives constructional details for chambers designed to give accurate control of temperature and humidity in investigations on certain properties of glasses, *e.g.*, chemical durability and electrical resistivity. 5 figures. G.R.S.

**Determination of the transformation point of glasses from viscosity measurements.** E. JENCKEL AND A. SCHWITTMANN. *Glastech. Ber.*, **16** [5] 163–70 (1938).—The apparatus for determining viscosity in the range of the freezing-in temperature is described. A very definite value of the viscosity at the transformation point was found for a series of Jena glasses whose so-called transformation points have been very carefully determined under comparable experimental conditions. The dependence of the transformation point on composition was determined for a series of $Na_2O$–$SiO_2$ glasses. Satisfactory results were obtained only in the range 17 to 35% $Na_2O$, due to crystallization. The effect of cations on the position of the transformation point for borate glasses was investigated. It is approximately proportional to the melting point of the metal oxide. The temperature coefficient of viscosity of chemically similar glasses runs similar to thermal expansion. This could be derived from one of Andrade's viscosity formulas (*Phil. Mag.*, **17**, 698 (1934); *Ceram. Abs.*, **13** [5] 133 (1934)). The effect of elastic after working on the freezing-in temperature was also investigated. J.F.H.

**Disclosure of glass structure from fluorescence observations.** R. THOMASCHEK AND O. DEUTSCHBEIN. *Glastech. Ber.*, **16** [5] 155–63 (1938).—The fluorescence spectrum of europium in salt solutions, in glass melts, and in crystallized glass melts was studied. The glassy state is characterized by a spectrum type distinct from those obtained from the crystalline or liquid states. The nature and position of the spectral lines give definite information about bonding strength and the nature of the fields of force in the vicinity of the light-emitting atoms. Three samples of MgO prepared by various methods could be definitely distinguished by this method, though they were identical by X-ray examination. The method is thus valuable in the study of fine structure of matter. Results are in agreement with the views of Zachariasen (*Ceram. Abs.*, **12** [4] 145 (1933)) on the structure of glasses. J.F.H.

**Discussion of "Presence of compounds in molten glass."** G. HEIDTKAMP AND K. ENDELL. *Jour. Soc. Glass Tech.*, **21** [84] 263 (1937); see *Ceram. Abs.*, **16** [1] 14 (1937). G.R.S.

**Effect of atmosphere on the viscosity and surface tension of a simple glass.** A. E. J. VICKERS. *Jour. Soc. Chem. Ind.* [London], **57** [1] 14–22 (1938).—The glass was composed of 67.3 $SiO_2$ and 32.7% $Na_2O$. Viscosity measurements were made within the temperature range 975° to 1150°C. At the lower temperatures air, $CO_2$, steam, hydrogen, ammonia, and $SO_3$ produced widely different effects on the viscosity of the glass. $SO_3$ at 1000° brings the viscosity down from 1550 to 980 poises and steam lowers the viscosity from 1550 to 1160. Increased fluidity with increasing temperatures was noted for all the gases, $SO_3$ producing the greatest increase. Surface tension of glass measurements obtained by the bubble-pressure method showed that gases reduce the values, a greater reduction occurring at higher temperatures to 1250°C. When the glass crystallized, the surface tension of the melt decreased. G.R.S.

**Effect of small additions of alumina on reactions in the mixture $6SiO_2+Na_2CO_3+CaCO_3$.** J. E. STANWORTH AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **21** [85] 299–309 (1937).—The addition of progressive amounts of calcined alumina up to approximately 5% to 1-g. charges of a mixture of the molecular composition $Na_2CO_3 \cdot CaCO_3 \cdot 6SiO_2$ has no measurable effect on the rate of decomposition at 700° or upon the amount of reacted silica formed. Some of the alumina, however, is rendered soluble in acid, owing to reaction with sodium carbonate. Alumina does not react with calcium carbonate or with silica to any appreciable extent, even at 800°. The addition of alumina increases the rate of decomposition of a mixture of sodium and calcium carbonates, owing to reaction with the former. In the complex mixture, however, where silica is also present, the reaction between alumina and sodium carbonate is relatively too small to affect appreciably the rate of decomposition. The addition of up to 5% of alumina decreases the melting rate, but the effect is less marked as the melting temperature is raised from 1100° to 1400°; at 1400° it is slight. The presence of fine seed, however, is a feature of the melts containing alumina at 1100° to 1400°. G.R.S.

**Effect of small additions of sodium sulfate on the reactions in the mixture $6SiO_2+Na_2CO_3+CaCO_3$.** J. E. STANWORTH AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **21** [86] 359–67 (1937).—Addition of amounts up to 5% of sodium sulfate to a mixture of the molecular composition $6SiO_2 \cdot Na_2CO_3 \cdot CaCO_3$ has no noteworthy effect on the rate of decomposition at 700° or on the amount of soluble silica formed at 700° or 800°. At temperatures of 1200° to 1400°, the mixture without sodium sulfate begins to melt sooner than that containing from 1 to 3% sodium sulfate added in molecular replacement of carbonate; with 5% sodium sulfate the rate of melting at 1400° is practically the same or even slightly quicker than that of the sodium carbonate mixture only. At all temperatures from 1200° to 1400°, the elimination of small seed is improved by the addition of 1 to 5% sulfate. At 1400° much of the decomposition of sulfate in the mixture takes place in the early stage of the melting process, and thereafter loss of residual $SO_3$ is slow. G.R.S.

**Effect of small additions of water on the reactions in the mixture $6SiO_2+Na_2CO_3+CaCO_3$.** J. E. STANWORTH AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **21** [85] 285–98 (1937).—The effect of water was studied in the temperature range 700° to 1400°. No appreciable reaction was observable at 700°; a slight reaction took place at 800°. Water has no effect on the melting and refining phenomena at temperatures of 1100° to 1300°. At 1400° the addition of 4.5% water reduces the seediness of the melt, but if 8% is added, the glass retains more seed. 3 figures. G.R.S.

**Effect of transverse scratches on the strength of sheet**

**glass.** A. J. HOLLAND AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **21** [87] 383–94 (1937).—The effect of transverse scratches made by a cutting diamond on the strength of strips of flat drawn sheet glass of mean thickness 0.275 cm. and 0.8 cm. wide has been investigated with particular reference to (1) load on the diamond when making the scratch, (2) time interval between scratching and breaking, and (3) rate of scratching. For loads less than 300 g. the strength was proportional to the scratch width, but above 500 g., increasing the load had little effect on the strength. The minimum width which brings about a reduction in strength for the ordinary cutting diamond is different from that for a conically ground and polished diamond or gramophone needle. The effect is probably dependent on the form of the scratch and on its depth. With low rates of scratching, the diamond scratch was not so efficient in reducing the strength of the strip, the greatest reduction in strength resulting from scratching at 8 cm./sec. The effectiveness of the scratch is reduced by increasing the time interval between scratching and breaking. The deviation of the breaking strength values from the mean was substantially less with scratched than with the unscratched specimens. 13 figures. See "Breaking—," *Ceram. Abs.*, **17** [1] 11 (1938). G.R.S.

**Effects of grinding and polishing on glass surfaces.** G. SCHIEB. *Oesterr. Glaserztg.*, **3**, 54–56 (1938).—Investigations by S. support the more recent experiments of Brandt (this issue, p. 302), Haberland, Neubert, and Werner that polishing is a continuation of fine grinding and does not involve a Beilby layer. J.F.H.

**Elastico-viscous properties of a soda-lime-silica glass at temperatures near the transformation point. Criticism.** V. H. STOTT. *Jour. Soc. Glass Tech.*, **21** [86] 356–58 (1937); see *Ceram. Abs.*, **17** [8] 273 (1938). **Reply to criticism.** N. W. TAYLOR. *Jour. Soc. Glass Tech.*, **21** [88] 450–52 (1937).—There is no contradiction between Stott's results (on an unstabilized glass) and those of Taylor, McNamara, and Sherman (on a stabilized glass). Stott's data on the relaxation from torsion of a glass fiber may be represented by an equation of the Adams and Williamson type, *i.e.*, $1/l - 1/l_0 = k_2 t$, or $-dl/dt = k_2 l^2$, plus an additional term which corresponds to $-dl/dt = k_1 l$. A molecular theory of these processes is briefly outlined. For details see *Jour. Amer. Ceram. Soc.*, **21** [3] 85–89 (1938). G.R.S.

**Electrical resistivity of glasses containing iron oxides.** SEIKITI MIYAGI. *Jour. Electrochem. Assn. Japan*, **6** [5] 164–67 (1938).—M. studied the difference in electrical resistivity of glasses containing iron oxide at varying temperatures in accordance with the oxidation degree of iron oxide. Experiments were made on borosilicate and lime-silicate glasses containing iron oxides up to 10%. The samples under experiment were two series of glasses which had the same molecular percentages of glass-composing oxides but different oxidation degrees of iron oxide; one was oxidized with $As_2O_3$ and $NaNO_3$, while the other was reduced by $H_2C_2O_4$ or cane sugar. The results showed that the reduced glass always had a higher specific resistance than the oxidized glass. Y.K.

**Evolution of the science and technique of glass.** P. SCHRADER. *Rev. Tech. Luxembourg.*, **30** [1] 6–28 (1938).—P. discusses the history of glass, its technical, physical, and optical properties, the diagram of the state of the system $SiO_2$–CaO–$Na_2O$, Na-Mg and Na-Al glasses, furnaces, and the development of glassmaking by machinery. Furnaces are described. M.H.

**Experiments with Thermolux glass.** J. POLÍVKA. *Tchéco Verre*, **5**, 56–59 (1938).—P. describes tests showing the superiority of Thermolux glass in regard to heat insulation over ordinary glazing and double glazing. See *Ceram. Abs.*, **15** [11] 330 (1936); **16** [1] 12 (1937). E.P.

**Fifty years of Hamburg enamel school.** ANON. *Deut. Glaserztg.*, **49**, 170–71 (1938).—The school was founded April 1, 1888, was reorganized in 1913, and is now incorporated in the State Technical School for the Wood and Building Trades. E.P.

**Filtering gas through glass.** W. H. ATKINSON. *Chem. & Met. Eng.*, **45** [4] 176 (1938).— A textile material composed of fibrous glass has been made commercially available for use as a filtering medium. This material overcomes the majority of objections previously raised to the use of fabric filters for gas filtration as it is heat resisting, is unaffected by moisture and acid constituents in the gas, and is less apt to cause "blinding" of the fabric than are cotton or wool filters. B.C.R.

**Glass block aides functional design of corrugated container factory.** ANON. *Mill & Factory*, **20** [4] 65–68 (1937).—A detailed and illustrated account of the use of glass block in the construction of a modern factory is given. Glass block replace windows, insuring insulation against heat and cold. The blocks are laid with a richer cement mortar in the window openings and are reinforced with 2-in. mesh every third course of block. The panels are calked with oakum, and mastic joints are inside and out. A 4-in. layer of glass wool lies under the roof-deck for insulation. D.A.B.

**Glass fibers for textiles.** J. L. TUCKER. *Glass*, **15** [1] 8 (1938).—T. reviews the uses and properties of fiber glass cloth. B.C.R.

**Glass in modern life: I, Glassware in the modern home.** J. H. HOGAN. *Jour. Soc. Glass Tech.*, **22** [89] 12–16 (1938).—H. discusses recent developments of glass as an architectural material. Special glasses to resist high heat and rough usage are mentioned. **II, Optical glass.** W. M. HAMPTON. *Ibid.*, pp. 16–19.—The term "optical glass" should only be applied to glass for scientific instruments of high precision. In recent years, the range of optical properties has been extended, notably in the direction of high refractive index combined with low dispersion. Certain glasses are so corrosive that no container has been found in which to manufacture them. Refractories always dissolve to some extent and modify the glass, sometimes in an undesirable direction. No iron-free refractory is used at present and glass containing iron has a lower light transmission than one containing no iron. Causes of striae are (1) solution of pot material, (2) selective volatilization from the surface of the glass during melting, and (3) incomplete mixing of raw materials persisting in spite of stirring operation. Refractories more resistant to corrosion are desired, the ultimate being one completely insoluble. **III, Building in glass.** RAYMOND MCGRATH. *Ibid.*, pp. 20–28.—M. traces the use of glass as a building material from early to modern times under the following headings: (1) development of the window, (2) glass and concrete construction, and (3) mirrors in architecture. **IV, Glass for general scientific and heat-resisting purposes. A review of British development, 1916–1937.** W. E. S. TURNER. *Ibid.*, pp. 28–42.—Tables give the compositions of 15 types of glasses available at different periods in the last 20 years. T. gives data on gases evolved from glass surfaces of known chemical composition during heat treatment *in vacuo*. In general, the chemical oxides which lead to low thermal expansion are also those which give high chemical durability. Examples of recent applications of scientific and heat-resisting glassware are given. **V, Glass and the lighting industry (1916–1937).** B. P. DUDDING. *Ibid.*, pp. 43–49.—D. discusses improvements in electrical properties of glass, its resistance to the action of metallic vapor, and its light-diffusing properties. 36 photographs. G.R.S.

**Glass silk (insulating material).** ANON. *Times Trade & Eng.*, **42** [889] xviii (1938).—Glass silk is made by drawing fine glass threads from the molten glass and spinning them while hot on a wheel. Glass silk is an ideal insulating medium as the fibers are wholly devoid of foreign particles, have no tendency to form large air-pockets, are chemically neutral, and will withstand handling without disintegration. It is supplied in the form of "blankets," slabs, tapes, yarns, and slivers. See *Ceram. Abs.*, **15** [11] 330 (1936); **17** [2] 63 (1938). A.B.S.

**Glass tape for insulation.** ANON. *Aero Digest*, **32** [6] 87 (1938).—A flexible glass tape for electrical insulation is made at Corning, N. Y. It is fabricated from glass yarn which has fibers ranging from $^1/_{15}$ to $^1/_{20}$ the diameter

of human hair. Its electrical, chemical, and heat-resisting properties are said to be exceptional. See "Fiber—," *Ceram. Abs.*, **17** [8] 273 (1938). L.F.M.

**Glass train.** ANON. *Oesterr. Glaserztg.*, **3**, 56 (1938).—In a train constructed in England, glass is used to the fullest extent. Illustrated. J.F.H.

**Glassware finishing machinery with special reference to tableware.** E. VENIS. *Jour. Soc. Glass Tech.*, **21** [86] 310–49 (1937).—Principal characteristics of the machines and features in their design are discussed. 33 figures. G.R.S.

**Imperial Tobacco's new building made of glass.** ANON. *Can. Machinery*, **48**, 115 (June, 1937).—The first glass brick building to be erected in Canada provides ideal conditions for a tobacco warehouse. D.A.B.

**Influence of strains on the variation of the refractive index of a glass.** NIUTA WINTER-KLEIN. *Compt. Rend.*, **206** [22] 1627–29 (1938).—Extensive and very exact measurements established the fact that changes in the refractive index in a glass are due only to mechanical stresses and not to changes in the physicochemical condition after annealing. See *Ceram. Abs.*, **16** [4] 116 (1937). M.H.

**Influence of surface tension in glassmelting processes.** H. JEBSEN-MARWEDEL. *Jour. Soc. Glass Tech.*, **21** [88] 436–41 (1937).—Surface tension is an important factor in the process of obtaining homogeneity in molten glass which may be a more or less intimate mixture of several different glasses. If the surface tension of the "embedded" glass is greater than that of its surroundings, the glassy inclusion tends to present the least possible surface through which the homogenizing process of diffusion can take place. Conversely, if the surface tension of the glassy inclusion is less than that of its surroundings, it tends to present the maximum possible surface of contact, and the diffusing and homogenizing processes are then greatly facilitated. 9 figures. See *Ceram. Abs.*, **17** [5] 177 (1938). G.R.S.

**Insulation properties of glass fiber.** JOHN COOPER. *Eng. & Boiler House Rev.*, **51** [7] 486 (1938).—C. discusses the properties and uses of a glass fiber insulating material having a wt./cu. ft. of 1.5 to 4.5 lb. and a thermal conductivity of 0.25 B.t.u./in./°F/hr. at 70°F. This material is recommended for use at temperatures up to 1000° F. Due to its chemical inertness it has been used successfully in the production of filter cloth. B.C.R.

**"Lightest" printing plant in the world.** ANON. *Mill & Factory*, **20** [6] 60–61 (1937).—The use of glass block for providing natural diffused light in a printing plant is illustrated. D.A.B.

**Machine for decorating sheet glass.** P. PROPASKY. *Deut. Glaserztg.*, **49**, 230–32 (1938).—P. describes the Protyp portable electric motor for driving grinding and engraving tools for the decoration of sheet glass. When the motor made 15,000 to 20,000 r.p.m. it became only hand warm. Work done by this means is illustrated. E.P.

**Measuring surface tension of glass by fiber weight method.** JAMES BAILEY. *Jour. Soc. Glass Tech.*, **22** [89] 38–40 (1938).—B. discusses the principles on which surface tension should be correctly derived from application of the fiber weight method. A new equation, $T = 981rls$, was deduced where $T$ = the surface tension, $r$ = radius of the fiber, $l$ = maximum length which can be supported by surface tension, and $s$ = specific gravity of the glass. Surface tensions obtained from this equation agree with those derived from the bubble method. G.R.S.

**Methods for determining the thermal endurance of glass.** R. J. WALLER. *Jour. Soc. Glass Tech.*, **21** [88] 463–75 (1937).—Tests were carried out to determine the difference in the thermal endurance values obtained when test pieces of glass rod are heated in a furnace in the horizontal and vertical positions under conditions otherwise similar. The average thermal shock values obtained for glasses of low thermal endurance were, for the two furnace positions, within 2°, but for Pyrex brand rods there was a difference of 15°, the tests in the vertical furnace giving the higher values. The thermal shock values decreased with increasing diameter of rod, the relationship appearing to be hyperbolic and tending to a finite positive value as the diameter increased. The results of previous workers were shown to fit similar curves. A suggested "standard procedure" for thermal endurance tests is given. 6 figures. G.R.S.

**Microscopical examination and identification of crystalline products in commercial glasses.** A. J. HOLLAND AND ERIC PRESTON. *Jour. Soc. Glass Tech.*, **21** [87] 395–408 (1937).—Frequently it is possible to examine and identify crystalline inclusions in glasses without preparing microscope sections. All the commonly occurring crystalline products so found possess the property of straight extinction, and the use of doubly polarized light is of value chiefly in the recognition of the different crystal species by their characteristic appearance when viewed between crossed nicols. Photographs are given showing the crystalline forms and habits of quartz, cristobalite, tridymite, wollastonite, pseudowollastonite, barium disilicate, kyanite, sillimanite, mullite, and corundum when found in commercial glasses. Deposition of sodium sulfate in sulfate boils and scabs, use of powder methods, Becke line test, and chemical analysis with reference to the identification of devitrite, sodium disilicate, and a magnesium aluminium silicate are illustrated. 84 figures. G.R.S.

**Possibility of preparing glasses containing $P_2O_5$, $Al_2O_3$, $B_2O_3$, and $SiO_2$.** J. E. STANWORTH AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **21** [87] 368–82 (1937).—A preliminary survey has been made of the possibility of glass formation from the oxides $P_2O_5$, $Al_2O_3$, $B_2O_3$, and $SiO_2$, with and without addition of basic oxides. A clear glass can not be made from silica and metaphosphoric acid alone, but can be derived by first preparing silicon phosphate. The addition of small amounts of $P_2O_5$, $Al_2O_3$, $TiO_2$, or $ZrO_2$ to boric oxide results in glasses which are opal on cooling or on subsequent softening. It does not seem probable that an extensive series of $P_2O_5$–$B_2O_3$–$SiO_2$ or $P_2O_5$–$B_2O_3$–$Al_2O_3$ glasses can be prepared. $Al_2O_3$–$SiO_2$–$B_2O_3$ mixtures containing only 5% $Al_2O_3$ may be melted at 1500° to clear glasses, provided the silica content is sufficiently high. $P_2O_5$–$SiO_2$–$Na_2O$ and $P_2O_5$–$Al_2O_3$–$Na_2O$ glasses may be prepared which contain only a limited amount of silica or alumina. Glasses containing $P_2O_5$–$B_2O_3$–$Na_2O$ are clear when sufficient $Na_2O$ is present and resistant to atmospheric attack with high percentages of $P_2O_5$. The limits of glass formation at temperatures up to 1600° have been determined in the series $Al_2O_3$–$SiO_2$–$Na_2O$, $Al_2O_3$–$SiO_2$–CaO, $Al_2O_3$–$SiO_2$–$B_2O_3$–$Na_2O$, and $Al_2O_3$–$SiO_2$–$B_2O_3$–CaO. With 15% CaO and 40% $SiO_2$ in the last series, as much as 40% alumina may be introduced into the glass. G.R.S.

**Purification of glassmaking sands on a commercial scale.** F. W. ADAMS. *Jour. Soc. Glass Tech.*, **21** [87] 409–14 (1937).—A. describes the sand purification plant erected at Leziate, Norfolk, by Joseph Boam, Ltd. Various types of Lynn sand were first purified in a small pilot plant. An output of 10 tons / hr. of treated sand is obtained from the plant. 1 figure. G.R.S.

**Russian glass industry.** ANON. *Diamant*, **60**, 125 (1938).—In addition to the usual manufactures, Russia has now undertaken the production of optical and safety glass, laboratory ware, glass wool, pharmaceutical ware, new types of hollow ware, and glass insulators. Of the window glass, 85% was produced mechanically, chiefly by the Fourcault process. In 1937 the production of window glass was 97.7 million sq. m., slightly in excess of the planned production of 81.4 sq. m. under the Five Year Plan. E.P.

**Society's twenty-first anniversary.** ANON. *Jour. Soc. Glass Tech.*, **22** [89] 50–67 (1938). G.R.S.

**Special alloys in the glass industry.** MICHAEL PARKIN AND W. E. S. TURNER. *Jour. Soc. Glass Tech.*, **21** [84] 247–62 (1937).—A survey based largely on the results of a questionnaire is presented. G.R.S.

**Spun glass, its properties and uses.** V. ČTYROKÝ. *Sklářské Rozhledy*, **15**, 1–8 (1938).—Methods of manufacture of glass fiber are described. Usual fiber diameters range from 0.01 to 0.003 mm. diameter, the tensile strengths varying from 1500 to 10,000 kg./cm². Glass wool, of density such that 1 m.³ weighed 80 to 110 kg. and consisting of only 4% by volume of glass, was an excel-

lent heat insulator. The following comparative heat conductivities are quoted: iron 50 to 70, concrete 1.3, mortar 0.75, glass 0.65, wood 0.39, asbestos 0.17, infusorial earth 0.12, and glass wool 0.03. Illustrated. E.P.

**Standard specifications for laboratory glassware.** ANON. *Ann. Chim. Anal. Chim. Appl.*, **20** [5] 115–21 (1938).—A questionnaire sent out by the French Association for Standardization refers to ground fittings, taps, and Kipp-type gas-producing apparatus. R.W.D.

**Statistical methods applied to the manufacture of spectacle glass.** C. E. GOULD AND W. M. HAMPTON. *Jour. Soc. Glass Tech.*, **21** [84] 235–46 (1937).—The problem of separating the effect on quality of the many variables was approached by statistical methods. Selected samples were marked for seeds and veins and the results were recorded over several years. Correlation coefficients were calculated for various associations of the data, and attempts have been made to connect such factors with the conditions of manufacture. Variation of refractive index over many meltings is also discussed. 6 tables. G.R.S.

**Steel, concrete, glass.** J. FULTNER. *Tchéco Verre*, **5**, 3–10 (1938).—Modern home and store buildings are shown. Interesting features are the employment of glass in the construction of a waterless gasometer by the Vitkovice Steelworks and the use of splinterless "Thorax-Restex" (Muhlig-Union) glass in the glazing of the openings of a girder rail in bridge construction. E.P.

**Thermal endurance of glass: III.** TARO MORIYA AND KOZO TABATA. *Jour. Soc. Glass Tech.*, **21** [84] 232–34 (1937).—The effect of initial stress on the thermal endurance of glass was investigated, using rods of borosilicate glass 5 mm. in diameter and 30 mm. long. The stress in the glass rod was measured by the Babinet compensator method. Results showed that the thermal endurance of a glass rod increases with increase in the apparent stress present. 3 figures. For Part I see *Jour. Amer. Ceram. Soc.*, **17** [2] 34–38 (1934); for Part II see *Ceram. Abs.*, **17** [4] 139 (1938). G.R.S.

**Views on the nature of glass.** J. E. STANWORTH. *Jour. Soc. Glass Tech.*, **21** [88] 442–49 (1937).—An attempt has been made to explain the changes in the physical properties of a glass as it cools down from its founding temperature. S. concludes that a gradual decrease in average coördination takes place and that at lower temperatures, particles over small volumes cease to be capable of relative movement. Time is necessary for these changes so that the physical properties depend on thermal history. 5 figures. G.R.S.

**X-ray diffraction study of soda-boric oxide glass.** J. BISCOE AND B. E. WARREN. *Jour. Amer. Ceram. Soc.*, **21** [8] 287–93 (1938).

### BOOKS

**Art of Glassmaking.** SIDNEY WAUGH. Dodd, Mead and Co., Inc., New York, 1937. 34 pp., 16 illustrations. Price $1.00. This book is devoted to processes in simple, entertaining, and instructive language. Glass qualities, desirable and undesirable, and the method of judging them are briefly stated. W. describes (1) flowing methods and tools; (2) the art and science of attaching handles, cutting, engraving, polishing, and decorating; and (3) the forming of the stem and foot, the shearing, the rounding of the lip, and the detaching of the finished ware from the tool, not only for goblets but also for urns and other objects. This book is an excellent primer on the hand making of art glass. An extensive bibliography is included. Illustrated. R.C.PURDY

**Glass in Architecture and Decoration.** RAYMOND MCGRATH AND A. C. FROST. 660 pp. Price 63s. Reviewed in *Glass*, **15** [3] 110 (1938). Illustrated. B.C.R.

### PATENTS

**Annealing leer.** W. O. AMSLER (Frazier-Simplex, Inc.). U. S. 2,120,452, June 14, 1938 (June 19, 1935).

**Apparatus for:**

**Intermittent production of rolled glass plates.** F. E. SLOCOMBE (Pilkington Bros., Ltd.). U. S. 2,120,912, June 14, 1938 (July 7, 1934).

**Making glass.** H. F. HITNER (Pittsburgh Plate Glass Co.). U. S. 2,122,469, July 5, 1938 (Sept. 10, 1936).

**Sealing metal to glass.** J. F. DONOVAN AND F. J. MALLOY (General Electric Co.). U. S. 2,121,627, June 21, 1938 (Oct. 11, 1935).

**Severing glass rod and tubing.** C. A. BROWN AND C. E. HAHN (General Electric Co.). U. S. 2,120,853, June 14, 1938 (July 29, 1936).

**Surfacing glass sheets.** H. S. HEICHERT AND WILLIAM OWEN (Pittsburgh Plate Glass Co.). U. S. 2,122,466, July 5, 1938 (April 16, 1936).

**Artificial dentures and method of making.** CORNING GLASS WORKS. Brit. 485,661, June 9, 1938 (July 6, 1936).

**Automatic glassblowing and suction machine.** SOC. ANON. D'ÉTUDES ET DE CONSTRUCTIONS D'APPAREILS MÉCANIQUES POUR LA VERRERIE. Ger. 657,260, Feb. 10, 1938 (May 2, 1935); VI/32*a*. 13. An automatic glassblowing and suction machine for manufacturing hollow glass articles of large content (glass balloons) has several aspirators moving around a common middle shaft. The machine has only a single prepared mold, which gives the preliminary shape to lumps of glass one after the other. D.A.B.

**Compound safety glass.** FRITZ ECKERT. Ger. 657,447, Feb. 17, 1938 (Feb. 13, 1932); XII/39*a*. 17.50. Two or more glass plates are joined by unbreakable, transparent layer(s). One or more of the glass plates to be used are less than 5 mm. in thickness and have been tempered to the desired degree of hardness by air cooling. D.A.B.

**Device for blowing and cooling glassware.** K. E. PEILER (Hartford-Empire Co.). U. S. 2,123,145, July 5, 1938 (Oct. 30, 1936).

**Double-walled (hollow) glassware.** ALBERT GÜNTHER. Ger. 657,533, Feb. 24, 1938 (Aug. 17, 1936); VI/32*a*. 27. A material is used as a spacer for the inner and outer flasks during the union of these two flasks. A metal plating liquid is admitted which either dissolves or combines with the spacing substance. D.A.B.

**Feeding molten glass.** BERNHARD ENGELS. U. S. 2,121,143, June 21, 1938 (Aug. 3, 1935).

**Felted fibrous products such as batts or mats of mineral wool fibers and a method and apparatus for making.** A. H. STEVENS (Johns-Manville Corp.). Brit. 487,161, June 29, 1938 (Dec. 15, 1936).

**Frosted glass bulb.** KEIKICHI OKUYAMA. Can. 374,645, June 21, 1938 (June 26, 1937). G.M.H.

**Furnaces for use with machines for manufacturing glass articles.** W. B. MITCHELL. Brit. 485,858, June 9, 1938 (Nov. 21, 1936).

**Glass-article manufacture.** OTTO FRITZE AND ALFRED RUTTENAUER (Canadian General Electric Co., Ltd.). Can. 374,336, June 14, 1938 (Feb. 21, 1935). G.M.H.

**Glass feeder.** H. M. BLACK (McKee Glass Co.). U. S. 2,121,945, June 28, 1938 (March 26, 1935).

**Glassforming machine.** THOMAS C. MOORSHEAD (United Glass Bottle Manufacturers, Ltd.). Can. 374,604, June 21, 1938 (Nov. 26, 1936). G.M.H.

**Glass nozzle.** ALEXIS W. KEEN (International Latex Processes, Ltd.). Can. 374,106, May 31, 1938 (Nov. 27, 1936; in U. S., Jan. 10, 1936). G.M.H.

**Glassworking press.** LEVI F. GOODRICH (Corning Glass Works). Can. 374,553, June 21, 1938 (Feb. 2, 1937; in U. S., March 16, 1936). G.M.H.

**Glazed roofing.** BERNARD LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). Can. 374,419, June 14, 1938 (Aug. 15, 1936). G.M.H.

**Laminated glass.** E. W. REID (Union Carbide and Carbon Corp.). U. S. 2,120,628, June 14, 1938 (March 25, 1937).

**Machine for the manufacture of glass articles.** BRIT-

ISH BOTTLES, LTD., AND S. HUNT. Brit. 486,842, June 22, 1938 (Dec. 14, 1937).

**Making inside frosted electric lamp bulbs.** L. E. CALKINS AND O. S. LEVI (Save Electric Corp.). U. S. 2,122,512, July 5, 1938 (July 29, 1936). The method of inside frosting thin hollow glassware such as lamp bulbs consists in injecting three successive shots of a glass-etching fluid, each for approximately two seconds, against the interior of the ware in a position to flow down over all of the surface to be etched, the solution containing the following ingredients in approximately the proportions named:

| | |
|---|---|
| Ammonium acid fluoride | 33 lb. 3 oz. |
| 60% hydrofluoric acid | 10 liters |
| Sodium acid sulfate | 11 lb. 1 oz. |
| Sodium fluoride | 11 lb. 1 oz. |
| Molasses | 12 liters |
| Water | 6 liters |

flowing water at approximately 63°C over the exterior of the surface for approximately the same length of time that the etching fluid is flowing over the interior of the surface, and thereafter washing out the interior of the surface with fluid under a higher pressure than that at which the etching fluid is impinged upon the interior of the ware.

**Manufacture of glass threads.** GEDEON V. PAZSICZSKY. Ger. 659,039, March 31, 1938 (Nov. 14, 1935); VI/32*a*. 25. The temperature of a quantity of glass contained in a melting crucible is increased constantly with the depth of the crucible, so that the molten glass emerging from an opening in the crucible shows the highest degree of heat. D.A.B.

**Manufacture of glass vessels.** BRITISH THOMSON-HOUSTON CO., LTD. Brit. 486,325, June 15, 1938 (Jan. 3, 1936).

**Manufacture of multicellular glass.** BERNARD LONG (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 2,123,536, July 12, 1938 (May 27, 1935). The process for the manufacture of multicellular glass comprises mixing solid comminuted vitreous substances with a pulverized substance capable of giving up gases, heating the mixture to a temperature at which the particles of the comminuted substance become soft and are joined to each other by mere contact, the second-mentioned substance being capable of producing gases at that temperature, interrupting the heating when the gases developed within the vitreous mass increase the volume thereof to the desired extent whereby cells are formed which are separated one from the other, and then cooling the mass, whereby multicellular glass of predetermined apparent density is produced.

**Manufacture of sheet glass.** L. P. FORMAN AND WILLIAM PANCOAST (American Window Glass Co.). U. S. 2,121, 958, June 28, 1938 (Oct. 23, 1936).

**Melting and refining glass.** W. A. MORTON (Amco, Inc.). U. S. 2,123,544, July 12, 1938 (Feb. 14, 1935).

**Method and apparatus for annealing glassware.** W. O. AMSLER (Hartford-Empire Co.). U. S. 2,120,947, June 14, 1938 (May 18, 1936). HARTFORD-EMPIRE CO. Brit. 487,227, June 29, 1938 (Dec. 14, 1935).

**Method and apparatus for producing corrugated glass sheets.** LOUIS BOUDIN AND HENRI POEYMIROU (Soc. Anon. des Manufactures des Glaces & Produits Chimiques de St. Gobain, Chauny & Cirey). U. S. 2,122,083, June 28, 1938 (July 30, 1935).

**Method and device for winding threads or filaments of glass, etc.** SCHLESISCHE SPIEGELGLAS-MANUFACTUR C. TIELSCH GES. Brit. 487,118, June 29, 1938 (Oct. 1, 1936).

**Molten glass feeding apparatus.** DONALD E. SHARP. Can. 374,651, June 21, 1938 (Nov. 20, 1936; in U. S., Feb. 27, 1936). G.M.H.

**Multicellular glass sheet manufacture.** R. J. A. INGOUF (Blue Ridge Glass Corp.). Can. 374,090, May 31, 1938 (Feb. 16, 1937; in U. S., March 2, 1936). G.M.H.

**Multifocal lens.** FAY D. KINNEY (American Optical Co.). Can. 374,359, June 14, 1938 (Jan. 8, 1937). G.M.H.

**Multifocal lens and blank.** JAMES H. HAMMON. Can. 374,156, May 31, 1938 (Dec. 11, 1936). G.M.H.

**Phosphate glasses for parts exposed to vaporous alkali or other light-metal liquids.** I. G. FARBENINDUSTRIE A.-G. Ger. 654,925, Aug. 17, 1935; *Chem.-Ztg.*, **61** [103–104] 1018 (1937). D.A.B.

**Producing a heat-insulating material out of glass.** V. STRAKA, B. WEINER, AND J. KLOUBEK. Brit. 486,623, June 22, 1938 (April 1, 1937).

**Producing vitreous, translucent, nonporous silica articles and articles produced thereby.** J. A. HEANY. Brit. 486,158, June 15, 1938 (March 16, 1937).

**Table for glass plates.** AKT.-GES. DER GERRESHEIMER GLASHÜTTENWERKE VORM. FERD. HEYE. Ger. 656,222, Jan. 20, 1938 (Dec. 9, 1935); VI/32*a*. 28. A table with a fireproof top (particularly a conveying or receiving table) for glass plates, etc., is described. The top of the table consists of single, elastic-coupled, fireproof units held together by U-shaped couplings, and the table is mounted in a frame work with a spring. D.A.B.

**Tempering glass.** W. B. CLITHEROW (American Securit Co.). U. S. 2,122,088, June 28, 1938 (Sept. 6, 1935).

**Tempering glass.** FRITZ ECKERT. Ger. 657,363, Feb. 17, 1938 (Feb. 13, 1932); VI/32*a*. 30. Glass heated almost to the softening point is rapidly cooled, by gases or by vaporous or atomized liquid cooling agents, to a temperature lying near, yet below, the limit of expansion of the considered glass; the cooling must reach the innermost part of the glass. The glass is then slowly cooled to the finish. D.A.B.

**Tempering glass.** HERZOGENRATHER SEKURITGLASWERKE, G.M.B.H. Ger. 657,430, Feb. 17, 1938 (Feb. 14, 1935); VI/32*a*. 30. Tempering is brought about by a gaseous or vaporous cooling agent, the movement of which alters constantly and is parallel to the glass surface. D.A.B.

**Vacuum-tight sealing of tungsten or molybdenum conductors through quartz glass or glasses of high silica content.** GENERAL ELECTRIC CO., LTD. (Patent-Treuhand-Ges. für Elektrische Glühlampen). Brit. 485,786, June 9, 1938 (Feb. 12, 1937).

## Structural Clay Products

**Brick road experiments in Ohio.** R. R. LITEHISER. *Proc. Highway Research Board*, **15**, 170–80 (1935); see *Ceram. Abs.*, **17** [4] 141 (1938). H.M.R.

**Design of brick surfaces to obviate slipperiness.** G. F. SCHLESINGER. *Proc. Highway Research Board*, **14** [Part I] 187–99 (1934); see "Production—," *Ceram. Abs.*, **14** [8] 188 (1935). H.M.R.

**Determination of water absorption of brick.** O. DRÖGSLER. *Tonind.-Ztg.*, **61** [39–40] 444 (1937).—The proportion of the absorption by immersion for 48 hr. at 24°C ± 2° to the pore volume is expected to give more definite results than the old factor $C_{24}:B_5$. The average absorption of 146 brick of standard size was 21.79 when completely immersed for 24 hr., 23.79 when gradually immersed, 23.79 when boiled for 3 hr. and weighed while hot, and 25.32% when left overnight to cool. The brick were of good quality and withstood 25 freezing cycles without damage. During the exceptionally hard winter of 1928 to 1929, they lost 8% in strength. D. defends the absorption tests as a valuable short-time determination of the resistance to weathering. W.K.

**Manufacture of vitrified brick in ordinary brickworks.** A. MÖSER. *Tonind.-Ztg.*, **61** [42] 465–67 (1937).—Since the manufacture of vitrified brick involves a fundamentally different firing process, the help of a competent ceramist or a ceramic laboratory should be sought when a change from ordinary brick is considered. The most important question is the raw material, *i.e.*, whether the avail-

able clays are suited to the purpose. The body should be carefully prepared. Firing in the ordinary annular kiln presents a problem, and M. makes several suggestions for adapting the kiln to the new product. W.K.

**Mortality curve study of the actual service lives of brick-on-concrete pavements, Des Moines, Iowa, 1909–1928.** A. MARSTON. *Proc. Highway Research Board*, **14** [Part I] 49–60 (1934).—The collection, arrangement, and calculation of the data are explained and illustrated. M. gives the resulting curves and the method of using them to aid in estimating the probable lives of similar pavements still in service. H.M.R.

**Preliminary studies of the actual service lives of pavements.** R. WINFREY. *Proc. Highway Research Board*, **15**, 47–60 (1935).—W. gives a report on actual service lives realized from various types of pavements in Buffalo, N. Y., Des Moines, Wayne County, Mich., and in the State highway systems of Mass. and R. I. Statistical methods are briefly described and forces that cause retirement are discussed. H.M.R.

**Problems connected with porous building materials.** D. R. G. BONNELL. *Chem. & Ind.*, **57** [9] 195–98 (1938).—B. discusses the rate of evaporation of water from a porous body containing a large number of pores of different sizes. Frost action, crystallization of salts, and moisture movement are treated. G.R.S.

**Report of Project Committee on Fillers and Cushion Courses for Brick and Block Pavements.** J. S. CRANDELL. *Proc. Highway Research Board*, **13** [Part I] 300–302 (1933). C. describes the use of temperature-resisting cement, a bituminous compound known as Zorbit, an asphalt-rubber compound, and Trinidad asphalt. To facilitate filler removal, the brick were coated with whitewash, calcium chloride, or several proprietary materials, all of which are successful with proper precautions and methods. A discussion is included. See *Ceram. Abs.*, **11** [2] 107 (1932). H.M.R.

**Strength of large brickwork piers.** O. HANSSON. *Tonind.-Ztg.*, **62** [4] 41–43; [5] 54–57 (1938).—H. gives a preliminary report on tests on the compressive strength of brickwork piers carried out at the Chalmer's bureau for Testing Materials in Göteborg. Fifty-seven piers, 3 m. high and 1 to $1^1/_2$ brick deep, were constructed. The brick were classed according to their volume weight, and from each class a large number of single brick were tested for weight by volume, compressive strength, and modulus of rupture. Various kinds of mortar used were also tested and controlled. The piers were built in the open air and tested when 90 days old with a movable compressing apparatus. The results are represented in well-arranged tables. Illustrated. W.K.

PATENTS

**Brick and block wall reinforcing.** J. P. BEM. U. S. 2,121,943, June 28, 1938 (May 4, 1937).

**Brick for building purposes.** C. W. BROWN AND G. D. PARKER. Brit. 486,458, June 15, 1938 (Jan. 6, 1937).

**Fabricated brick wall panel construction.** E. V. POSTON. U. S. 2,122,696, July 5, 1938 (Feb. 10, 1937).

**Structural element.** C. H. MILLER (Universal Sewer Pipe Co.). U. S. 2,123,853, July 12, 1938 (May 13, 1936). A hollow block comprises two external walls substantially equispaced throughout their extent, two webs therebetween substantially equispaced from each other and from the walls, connecting sides extending between the external walls and across the webs, one of the walls being displaced from the webs in one direction and the other wall displaced from the webs in the opposite direction.

**Tile or slab made from ceramic materials, etc.** F. W. GRUNDY (Rainford Potteries, Ltd.). U. S. 2,120,742, June 14, 1938 (Feb. 9, 1934; Aug. 20, 1936). A hollow polygonal clay body.

## Refractories

**Alkali content of kyanite.** J. JAKOB. *Schweiz. mineralog. petrog. Mitt.*, **17**, 214–19 (1937).—Chemical analyses of crystals of kyanite from three sources are given. All contain a fairly constant amount of alkali, principally $Na_2O$, in the approximate molecular ratio of $40SiO_2 : 40Al_2O_3 : 1Na_2O$. Combined water is present in a quantity varying between $1Na_2O:1H_2O$ to $1Na_2O:3H_2O$. The densities range from 3.527 to 3.648. A definite quantity of alkali is necessary to stabilize the kyanite modification. H.I.

**Boiler refractories.** ANON. *Eng. Boiler House Rev.*, **51** [7] 502 (1938). B.C.R.

**Development in insulating refractories.** ANON. *Mill & Factory*, **20** [5] 217 (1937).—Insulating refractory brick with a calcined firebrick base are described. Eleven types are mentioned. D.A.B.

**Errors in working up fire clay.** RUDOLF RASCH. *Tonind.-Ztg.*, **61** [46] 511–12; [47] 526–27 (1937).—Each clay particle must be thoroughly soaked with water which is best attained by drying and grinding the clay; otherwise prolonged aging is necessary. If soaked properly, the clay undergoes a self de-airing process. Frozen clay must be completely disintegrated. Clay and grog should not be ground together. A certain percentage of coarse as well as of very fine grog is important for good heat resistance. W.K.

**Experimental and numerical determination of the heat conductivity of hollow brick.** E. RAISCH AND W. WEYH. *Gesundh.-Ing.*, **60** [37] 565–67 (1937); abstracted in *Physik. Ber.*, **19** [3] 299 (1938).—A method of calculating the heat conductivity of hollow brick was developed on the basis of experiments with brick in which the hollow spaces were replaced by pieces of a poor heat conductor of known heat conductivity. M.H.

**Glass tank refractories.** WALTER A. STERNER. *Ind. Gas*, **16** [12] 11, 20 (1938).—S. describes the manufacture of glass tank refractories in gas-and coal-fired kilns. S.S.

**High aluminous cements.** W. E. PATTERSON. *Jour. Can. Ceram. Soc.*, **7**, 22 (1938).—The results of simple comparative tests of two high-alumina cements are given. J.G.P.

**High alumina refractories.** CHARLES J. WARD. *Jour. Can. Ceram. Soc.*, **7**, 19–21 (1938).—W. discusses high alumina refractories having diaspore as a base. The only known commercial deposits in North America are found in Missouri. The commercial grade of diaspore, with the shrinkage removed, has a fusion point of cone 39+. High alumina refractories are made by bonding diaspore grog with very pure semiflint clays. Advantages of high alumina brick over No. 1 quality fire brick are pointed out. J.G.P.

**Insulating brick.** ANON. *Mill & Factory*, **20** [3] 108 (1937).—An insulating brick made of high-quality clay and a specially manufactured lightweight fibrous inorganic aggregate is described. It is light weight and has a low thermal conductivity, $^1/_6$ of that of fire brick. D.A.B.

**Manufacture of glass blocks.** JAMES A. LEE. *Chem. & Met. Eng.*, **45** [4] 185 (1938).—L. describes the equipment and processes used for manufacturing glass blocks. The blocks are made in halves which are sealed together while still at a high temperature. After annealing and cooling they are tested for leaks by immersion in water. B.C.R.

**Manufacturing magnesitic brick in Canada.** J. W. CRAIG. *Jour. Can. Ceram. Soc.*, **7**, 25–35 (1938).—Basic refractories are essential to the operation of Canada's steel, copper, and nickel plants. The production of basic brick is an outgrowth of the established magnesitic dolomite industry. The manufacture of magnesitic brick in Canada centers around magnesia and chrome. Magnesia is produced locally; chrome is imported. Until 1927 the magnesitic rock was won by open pits, but stope mining is now carried out at several levels. The clinker is prepared by firing the crushed rock to high temperatures in rotary

kilns. Sized chrome and sized clinkers are combined in definite proportions, tempered in a conventional wet pan to a consistency slightly damper than is used for dry pressing, and molded into brick by a pneumatic method similar to that used in the production of silica brick. After careful drying, the brick are fired in a car tunnel kiln. C. discusses the chemistry of magnesia-chrome brick and shows how magnesia, chrome, and calcium silicates are combined to give desired properties. See *Ceram. Abs.*, **15** [11] 335 (1936). J.G.P.

**Phosphate smelting.** H. A. CURTIS, A. M. MILLER, AND R. H. NEWTON. *Chem. & Met. Eng.*, **45** [3] 116 (1938).—Processes used at the TVA phosphoric acid plant are described. The electric smelting furnaces are lined with high-alumina brick from the top edge to a point 1 ft. above the slag line. The floor of the crucible and the remaining portion of the side walls are lined with carbon blocks cut from old carbide furnace electrodes which must be replaced annually. B.C.R.

**Porosity of tank blocks.** A. MÖSER. *Tonind.-Ztg.*, **61** [79] 880–81 (1937).—Permeability is a better criterion of the quality of tank blocks than porosity. Fine pores are desirable, but they should not be too fine; otherwise they will exert too much capillary attraction on the slags. Permeability may be tested by measuring the speed of ascension of a dye solution or the rate of flow of water through a piece. High grog content increases the cost. The particle size distribution is important, but can not be calculated theoretically. The difference between the fraction sizes should be large and a certain amount of dust is essential to keep the pore size down and to cut down the formation of seeds. Whether the clay and the grog should be the same material is open to question. The best material today is shale and the best block is a 100% shale block. W.K.

**Refractoriness under load test.** H. C. BIGGS. *Jour. Soc. Glass Tech.*, **21** [85] 264–69 (1937).—B. indicates the essential requirements of methods of testing and describes new apparatus which meets these requirements, including means for eliminating the effect of expansion other than that of the specimen. 5 figures. G.R.S.

**Refractory concrete.** S. B. MACDONALD. *Jour. Can. Ceram. Soc.*, **7**, 15–18 (1938).—M. discusses refractory concretes which are held together, at least in the first stages, by a hydraulic cement, particularly calcium aluminate or high alumina cements. High alumina cement appeared during the World War. After the war there was a lapse of interest, but by 1921 in France and 1923 in the United States it was again being actively promoted. There have been several such cements produced in Europe but only one in America. Lumnite is essentially a monocalcium aluminate containing approximately 38 $Al_2O_3$, 36 CaO, and 15% iron oxide. Refractory concrete is a mixture of high alumina cement, a graded refractory aggregate, and water and is a structural concrete which develops a ceramic bond in use. The aggregates supply the refractory properties, and the cement provides the cold or prefired strength. Recommended procedures in preparing refractory concretes for various applications are given. J.G.P.

**Silica firestone.** W. A. O'BRIEN. *Refrac. Jour.*, **14** [4] 171 (1938).—The advantages of silica firestone as a cupola refractory depend upon its high fusion point, high resistance to abrasion at elevated temperatures, simplicity of application, and low cost. The difficulties caused from fired-out linings are discussed. Maintenance of constant and definite conditions in the cupola during the entire melting period is of great importance in securing a metal which will produce castings of desired qualities. B.C.R.

**Use of sand in assay crucible bodies.** R. J. MONTGOMERY. *Jour. Can. Ceram. Soc.*, **7**, 46–47 (1938).—It is probable that silica in reasonable amounts may be "loosely bonded" in the body and may improve the shock-resisting properties in spite of its rather large and irregular thermal expansion curve. Such expansions are probably local, crushing the loosely bonded structure and not damaging the body as a whole. J.G.P.

**Vacuum pressing refractory brick.** DWIGHT B. HENDRYX. *Chem. & Met. Eng.*, **45** [3] 121 (1938).—In manufacturing machine-made brick, the methods generally used are either the power-press or extrusion process. The vacuum principle may be applied to either method; in the former, it is termed vacuum pressing, in the latter, deairing. In the extrusion process, air entrapped in the clay during mixing in the pug mill is removed prior to passing the clay through the extrusion die, thus preventing the formation of laminations. Vacuum pressing allows the use of much higher forming pressures than were formerly possible, thus producing a much denser brick. H. describes the methods and explains the principles involved in each process. The presence of dust in the vacuum system of the power-pressing process created considerable difficulty and necessitated the construction of a specially designed valve with a soft rubber disk. Removal of dust is accomplished by ejecting the dust-laden air through very small openings under water. B.C.R.

BOOK

**Refractory Construction Materials** (Feuerfeste Baustoffe). CLAUS KOEPPEL. H. Hirzel, Leipzig, 1938. 296 pp., 51 illustrations. Price 17 Rm. K. thoroughly covers silica and siliceous bodies. The most important systems such as $SiO_2$, $Al_2O_3$–$SiO_2$, and Ca–$Al_2O_3$–$SiO_2$, the silica modifications, ceramic fluxes, and special oxides ($ZrO_2$, $TiO_2$, MgO, etc.) are discussed. Dolomite, magnesite, and forsterite brick are described, and their uses and physical properties are discussed in detail. This volume is one of the most up-to-date textbooks on refractories and should be of equal value to the student and the practical refractories engineer. L. E. THIESS

PATENTS

**Aluminum hydroxide production.** PAUL MOYER. Ger. 654,790, March 23, 1934; Cl. 12*m*. 6; *Chem.-Ztg.*, **61** [101] 995 (1937). D.A.B.

**Composite refractory body.** HALLAM E. MENDENHALL (Western Electric Co., Inc.). Can. 374,271, June 7, 1938 (Sept. 2, 1936). G.M.H.

**Drying of residues from alumina fabrication.** ZSCHIMMER & SCHWARZ, CHEMISCHE FABRIK DÖLAU. Ger. 654,749, Aug. 11, 1935; Cl. 12*m*. 5; *Chem.-Ztg.*, **61** [101] 995 (1937). D.A.B.

**Extracting aluminum oxide from raw material.** HELGE LÖFQUIST. Ger. 657,977, March 3, 1938 (Dec. 9, 1935); IV*b*/12*m*. 5. A small quantity of lead oxide is added to the molten mass of raw material which contains silicon dioxide in addition to the aluminum oxide; 3.8 parts of lead oxide are used to 1 part of silicon dioxide. The aluminum oxide is separated by crystallization from the slowly cooled mass. D.A.B.

**Furnace roofs and arches.** F. H. ROGER (H. Koppers' Industrieele Mij. N. V.). Brit. 487,196, June 29, 1938 (Dec. 17, 1936).

**Magnesia refractories.** E. J. LAVINO & Co. Brit. 487,213, June 29, 1938 (Feb. 2, 1937).

**Making cellular refractory bodies.** J. M. KNOTE (Quigley Co., Inc.). U. S. 2,122,288, June 28, 1938 (July 30, 1935). The process of making a cellular fire brick of low heat conducting capacity comprises shredding old newspapers and blowing the fragments through a fine screen to produce a fluffy mass of cellulose fibers, mixing such air-blown mass with a good quality of fire clay in about the proportions by weight of two parts clay to one of paper, tempering the mass with just sufficient water to render it plastic, molding under the lightest pressure possible to avoid reducing the original volume of the mass, drying, and firing the brick so formed.

**Manufacture of articles, *e.g.*, brick, from alumina cement and corundum.** DOUGLAS ANDERSON. Ger. 657,770, Feb. 24, 1938 (Aug. 1, 1935); VI/80*b*. 21.02. Finely pulverized alumina cement and finely pulverized sintered aluminum oxide (natural corundum, emery, etc.) are mixed with water and allowed to set; 1 to 4 parts of aluminum oxide are used to 1 part of cement. D.A.B.

**Manufacture of fireproof brick or linings.** MAGNE-

SITAL, G.M.B.H. Ger. 656,928, Feb. 3, 1938 (Nov. 10, 1934); VI/80*b*. 8.04. A mixture of corundum and chromite ore is molded and fired. Fine- or coarse-grained corundum or slag rich in alumina is used (30% by weight being 1 mm. in size); fine-grained chromite ore (0.3 mm.) is used to the extent of 50% by weight. D.A.B.

**Manufacture of pure alumina compound by heating clay to about 1000°C.** I. G. FARBENINDUSTRIE, A.-G. Ger. 654,557, Nov. 18, 1933; Cl. 12*m*. 6; *Chem.-Ztg.*, **61** [101] 995 (1937). D.A.B.

**Manufacture of refractory materials.** H. H. CHESNY AND A. L. BRADLEY. Brit. 486,899, June 22, 1938 (Dec. 12, 1936).

**Manufacture of sintered dolomite.** KLOCKNER-WERKE AKT.-GES. Brit. 486,490, June 15, 1938 (Sept. 1, 1936).

**Molding refractory crucibles.** R. AMAND. Brit. 486,826, June 22, 1938 (July 10, 1936).

**Obtaining aluminum oxide from siliceous material.** ELECTRIC SMELTING & ALUMINUM CO. Ger. 654,236, July 7, 1936; Cl. 12 *m*. 5; *Chem.-Ztg.*, **61** [100] 986 (1937). D.A.B.

**Production of aluminium oxide from bauxite and like aluminium-containing substances.** R. SCHOLDER. Brit. 486,255, June 15, 1938 (May 11, 1936).

**Recovery of aluminum compounds from aluminiferous minerals.** WILHELM FULDA, ERICH WIEDBRAUCK, AND KARL BÜCHE (Th. Goldschmidt A.-G.). U. S. 2,123,650, July 12, 1938 (Oct. 13, 1934).

**Refractory.** HENRY C. FISHER (Norton Co.). Can. 374,114, May 31, 1938 (Sept. 24, 1936; in U. S., Sept. 27, 1935). A refractory article comprises a molded body containing silicon carbide grains and bentonite. G.M.H.

**Refractory.** ALAN L. GORMLY (Norton Co.). Can. 374,115, May 31, 1938 (Sept. 24, 1936; in U. S., Sept. 27, 1935). A refractory article comprises over 97% crystalline alumina and a bond comprising, in part, bentonite. G.M.H.

**Refractory body and method of making.** KARL SCHWARTZWALDER (General Motors Corp.). U. S. 2,122,960, July 5, 1938 (Jan. 25, 1935). The method of making ceramic articles consists in preparing an intimate mixture of ceramic material and a binder, forming the material into preliminary shape, subjecting the preliminary shape to the combined action of heat and heavy pressure to produce the final shape, and firing the article to eliminate the binder and cohesively unite the ceramic material into a dense structure.

**Refractory brick or radiant for surface combustion burners.** ARTHUR DOCKING. U. S. 2,122,132, June 28, 1938 (Nov. 17, 1936).

**Refractory composition.** CHARLES E. MACQUIGG (Union Carbide & Carbon Research Laboratories, Inc.). Can. 374,429, June 14, 1938 (Nov. 23, 1936). G.M.H.

**Refractory composition and process for making.** UNION CARBIDE & CARBON RESEARCH LABORATORIES, INC. Brit. 485,871, June 9, 1938 (Dec. 11, 1935).

**Refractory insulation.** OTIS L. JONES (Illinois Clay Products Co. and F. E. Schundler & Co., Inc.). Can. 374,451, June 14, 1938 (May 27, 1937). G.M.H.

## Terra Cotta

PATENTS

**Colored roofing.** C. E. HILLERS (Blue Ridge Slate Corp.). U. S. 2,122,862, July 5, 1938 (Dec. 30, 1936). The process of color-coating roofing shingles, etc., comprises spreading a composition of intermingled alkali metal-silicate solution and powder over the surface of the roofing shingles, etc., the powder consisting of barium fluosilicate, coloring agent, and filler, and setting the composition.

**Terra cotta grinding machine.** F. Y. PEARNE AND G. P. FACKT (Gladding, McBean & Co.). U. S. 2,120,570, June 14, 1938 (Jan. 10, 1938).

## Whiteware

**Construction materials for installation technique.** FRITZ POLENZ. *Elektrotech. Z.*, **59** [10] 249–55 (1938).—P. discusses the manufacture of molded insulation materials, specifically ceramic bodies such as porcelain, steatite, etc. Such materials are molded in a more or less plastic condition, and their valuable characteristics are obtained only by a firing process, accompanied by shrinkage and sintering. Some steatite articles, where great precision of dimensions is desired, are first heated to red heat and then turned, machined, drilled, and tapped on special machines, similarly to metal. Automatic presses for steatite, a section of a turning department with drill presses and lathes for machining prefired steatite parts, and German ceramic insulation materials made by dry pressing are illustrated. L.E.T.

**Proposed modifications of the classification of ceramic dinnerware.** ARTHUR S. WATTS. *Bull. Amer. Ceram. Soc.*, **17** [7] 295–96 (1938).

**Use of nepheline syenite in ceramic products.** C. J. KOENIG. *Jour. Can. Ceram. Soc.*, **7**, 36–39 (1938); see *Ceram. Abs.*, **15** [3] 98 (1936). J.G.P.

PATENTS

**Closet bowl.** F. J. WOLFF. U. S. 2,121,940, June 28, 1938 (Dec. 7, 1936).

**Pottery making machine.** G. W. LANE. U. S. 2,120,253, June 14, 1938 (Oct. 27, 1936).

**Siphon breaking water closet.** R. A. BROOKS (I. B. Kerr). U. S. 2,122,834, July 5, 1938 (Dec. 23, 1932).

**Spark plug.** EMILE GUILLON AND JOSEPHAT PERRAULT. Can. 374,139, May 31, 1938 (Jan. 18, 1937). G.M.H.

**Spark plug.** ARTHUR C. HASTINGS, JR. Can. 374,474, June 14, 1938 (Dec. 18, 1936; in U.S., Jan. 16, 1936). G.M.H.

**Spark-plug insulator.** T. G. MCDOUGAL, A. H. FESSLER, AND KARL SCHWARTZWALDER (General Motors Corp.). U. S. 2,120,338, June 14, 1938 (Nov. 16, 1935). A spark-plug insulator made of recrystallized alumina together with crystalline aluminate of one of the metals of the second group of the periodic table having an atomic weight between 40 and 138.

**Ventilated toilet bowl.** WILLIAM HERRMANN. U. S. 2,122,687, July 5, 1938 (May 15, 1936).

**Vitreous bodies.** GENERAL ELECTRIC CO., LTD., M. PIRANI, AND J. H. PARTRIDGE. Brit. 486,444, June 15, 1938 (Dec. 2, 1936).

## Equipment and Apparatus

**Comparative tests made with Hatch and Greenburg-Smith impingers.** J. M. DALLA VALLE. *U. S. Pub. Health Repts.*, **52**, 1114–18 (Aug. 13, 1937).—While modifications of the Greenburg-Smith impinger have been made since its introduction in 1923, the basic impingement principle has not been affected. In 1932, Hatch, Warren, and Drinker described a modification of the impinger apparatus, since widely used. In response to numerous requests made to the Public Health Service, tests were made on 18 samples having dust concentrations ranging from approximations of 2 million to 8 million particles per cubic foot of air; the conditions of the experiments are fully described. Similar results were reported for the two instruments. An all-glass (Pyrex brand) impinger has

been constructed which is believed to embody the best features of the Greenburg-Smith and the Hatch impingers; the new type is described and illustrated. K.R.

**Corrosion by impact of falling drops.** G. WELTER. *Engineering*, **145** [3774] 521 (1938).—Tests in which a 3% NaCl solution was allowed to react upon metallic surfaces indicated that greater corrosion occurred when the solution was allowed to fall from a height of 5 m. than when the metallic surfaces were merely moistened with the liquid. B.C.R.

**Corrosion resistance of some alloy modifications.** R. MUELLER. *Chem. App.*, **25** [10] 153–54 (1938).—An alloy of 58 Ni, 20 Fe, 20 Mo, and 2% Mn withstands attack by concentrated HCl, concentrated chlorides, bromides, and fluorides. A table gives, for ten Ni alloys (with 56 to 99.4% Ni), the fields of application for concentrated and diluted $H_2SO_4$, HCl, $P_2O_5$, HF, $H_2S$, $HNO_3$, mixtures of them, oxides and chlorides, and some gases. These alloys also have a fairly good resistance to organic acids. M.H.

**Dehydration of minerals.** HENRI LONGCHAMBON. *Bull. Soc. Franç. Mineral.*, **59**, 145–61 (1936).—L. describes an apparatus to register automatically the loss in weight of minerals exposed to increasing temperature. The mineral under test rests on one pan of a balance, the pan being in the center of a resistance furnace. A mirror attached to the horizontal axis of the balance reflects light to a vertically suspended mirror attached to the temperature registering galvanometer of the furnace. The light is reflected to a film or photographic paper. The resulting curve has abscissa representing temperature and ordinate representing weight loss. A current of air saturated with water-vapor at a determined temperature is introduced into the furnace. H.I.

**Determining porcelain porosity with the microscope.** E. K. ZAVADOVSKAYA. *Zavodskaya Lab.*, **6**, 1021–22 (1937).—The Florenskiĭ and Zemyatchenskiĭ methods are criticized, as they give different results depending on the method of polishing and the magnification used. The necessity of standardizing the amount of polishing and the magnification at which inspection takes place is emphasized. P.B. & E.S.

**Device for determining viscosity and moisture content of green ware.** S. MAKARIN. *Stroitel. Materialy*, **1938**, No. 2, pp. 44–45. The device measures the pulling stress of an iron rod plunged into the brick and attached to a spring scale. The relation between viscosity and moisture content is shown graphically. P.B. & E.S.

**Device for determining the volume of brick.** M. F. LINTZOV. *Zavodskaya Lab.*, **7**, 114 (1938).—The brick is saturated with water after weighing and immersed in water in a box equipped with a gage glass. P.B. & E.S.

**Dust-collector unit.** ANON. *Can. Machinery*, **48**, 41 (May, 1937).—A device for removing dust and other foreign matter from air is described. D.A.B.

**Formula for determining the output of multichamber mills.** V. V. ALYAVDIN. *Tsement*, **5** [1] 33–43 (1938). P.B. & E.S.

**Furnace for determining carbon and sulfur by ignition.** F. K. GERKE. *Zavodskaya Lab.*, **7**, 236–37 (1938).—The furnace, constructed by the Refractories Inst., is equipped with a silicon carbide rod of the Globar type for 120 and 220 v. It can be used successfully instead of the Strohlein furnace with Silit rods. P.B. & E.S.

**Grindability *versus* mill capacity.** R. M. HARDGROVE. *Chem. & Met. Eng.*, **45** [5] 240 (1938).—Grindability is that characteristic of a substance which determines the capacity of a given pulverizer for reducing the material to a standard fineness and is directly proportional to the specific gravity of the material and inversely proportional to its crushing strength. H. describes the A.S.T.M. and Hardgrove methods of determining grindability. Grindability has little effect on total power costs, and data concerning it are chiefly used for determining the proper size of equipment to install. B.C.R.

**Grinding in closed circuit.** HENRY W. HITZROT. *Chem. & Met. Eng.*, **45** [5] 234 (1938).—Closed-circuiting of grinding equipment is the practice of removing material from the mill before it is completely ground, separating the material reduced to the desired size, and returning the oversize for further grinding. This method reduces the amount of fines produced and provides better control over particle size in addition to reducing power costs and decreasing wear of grinding surfaces. B.C.R.

**Instrument for counting and weighing particles of dust, smokes, and other dispersions.** S. C. BLACKTIN. *Jour. Soc. Chem. Ind.* [London], **56**, 281–83 (Aug., 1937).—The Electrotor Meter can be rapidly and conveniently used for either counting or weighing particles or both. As the Electrotor Meter can analyze a volume of dispersion from a few cubic centimeters to several liters, weighing of deposits can be applied either to dusts or smokes. The transparent film on which the record is received to be weighed and counted weighs only about 20 mg. The advantages of the instrument are outlined. See "Measuring—," *Ceram. Abs.*, **16** [4] 124 (1937). G.R.S.

**Mechanism of wear in metals.** THOMAS U. MATTHEW. *Jour. Roy. Tech. Coll.* [Glasgow], **4** [Part 2], 360–75 (1938).—M. discusses original research to determine a new method of studying wear mechanism in metals. Contact temperatures and friction forces on dry metal surfaces were investigated. X-rays indicated that the surface worn away is broken down to atomic units as in fatigue fragmentation. Hysteresis loss of a steel specimen at various temperatures was determined, using a torsion pendulum showing a maximum loss at 800°C. M. suggests that highly damped surface fatigue action causes the high temperatures found for the surfaces sliding in contact. W.H.B.

**Modified cell for dust counting.** CHARLES E. COUCHMAN AND WILMER H. SCHOLZE. *U. S. Pub. Health Repts.*, **53**, 348–50 (1938).—The Sedgwick-Rafter counting cells have been generally recognized as standard equipment, together with the Greenburg-Smith impinger, in evaluating the extent of dust exposures in industrial occupations. Quantification of the dust collected with the impinger equipment is desired, but as the Sedgwick-Rafter cell was originally designed for microscopical studies of water supplies, it has certain disadvantages in studying industrial dusts; six are listed by the authors. They describe the construction of a new cell eliminating these disadvantages which equals in accuracy the Sedgwick-Rafter cell, as shown in a tabulation of the comparative dust counts of 10 samples of industrial dusts. The advantages of the modified cell are given. Illustrated. 5 references. K.R.

**Ocular micrometer for use in dust counting.** RICHARD T. PAGE. *U. S. Pub. Health Repts.*, **52**, 1315–16 (Sept. 17, 1937).—The commonly employed technique for determining dust concentration in impinger air samples is practically a duplication of Whipple's technique in determining plankton concentration in drinking water, the standard micrometer used in the work usually being that designed by Whipple. P. describes the technique and the apparatus in detail. The whole field covered by the Whipple micrometer has been utilized in making plankton counts. In making dust counts, however, the dust is counted in only one quarter of each ruled field. Only one of the quadrants not containing the finely divided square is counted, the remaining three quadrants being unnecessary. To facilitate the counting of dust samples, a micrometer eyepiece was made according to a design shown. The ruled grid corresponding to one quadrant of the Whipple grid is located in the center of the visible field. The grid consists of an etched square, 3.5 mm. side measurement, divided into 25 small squares. Results obtained are identical with those obtained when counting one fourth of the Whipple field. Both micrometer eyepieces are being used for dust counting by the Division of Industrial Hygiene of the U. S. Public Health Service. Illustrated. 2 references. K.R.

**Portable apparatus for precise gas analysis.** S. W. SLEIGH. *Jour. Soc. Chem. Ind.* [London], **56**, 430–34 (Nov., 1937).—Differences from former instruments are described and shown in diagrams. The basis of accuracy is outlined. G.R.S.

**Pulverizing process materials.** ANON. *Chem. &*

*Met. Eng.*, **45** [5] 241 (1938).—Tabulated data are given of the types of disintegrating equipment used for the processing of 200 materials. B.C.R.

**Pycnometric method for specific gravity of heavy solids.** F. A. BANNISTER AND MAX H. HEY. *Mineralog. Mag.*, **25**, 30–34 (1938).—A pycnometer made of a straight capillary silica-glass tube, 9 cm. in length, 0.5 mm. in bore, and with walls 0.75 mm. thick, is described. Calibration is made by determining the weight of bromoform (on a microbalance) when filled to different heights as measured on a traveling microscope. The solids are introduced before or after evacuation to remove air bubbles. After introduction of the solid, the specific gravity can be calculated from the weights of the pycnometer, the length of the bromoform column at a known temperature, and the specific gravity of the bromoform. The accuracy of specific gravity determinations by several methods is discussed. H.I.

**Rapid micro-method for determining specific gravities of minerals and rock constituents.** MARTIN BEHRENS AND JULIUS HOLZNER. *Neues Jahrb. Mineral. Geol., Beilage Bd.*, **A71**, 373–84 (1937).—An apparatus for the determination of specific gravities of powdered minerals, etc., by the suspension method consists of a U-tube with a connection to a mercury reservoir at the lower end, an interconnection between the two arms near the top with a side tube to a dropper leading to the suspension tube (a centrifuge tube), and a wedge-shaped constriction in one of the arms of the U-tube. The arm of the U-tube containing the wedge is filled with a liquid of lesser density, and the other, with a liquid of greater density. By means of a stopcock, mercury is allowed to enter both arms, the two liquids overflowing through the upper connection and mixing in the suspension vessel. As the mercury rises in the U-tube, increasing proportions of the low-density liquid flow into the suspension vessel so that the resulting mixture is denser at the bottom and lighter at the top. The level at which the mineral particles float is noted, a small quantity of liquid from that level is withdrawn in a capillary tube by suction, and the density of the liquid is determined by measuring with a manometer the reduction in pressure over the liquid column in the capillary. Sample determinations on a number of minerals are given. H.I.

**Resistance of metals to attack by hydrochloric acid.** E. RABALD. *Chem. Fabrik*, **11**, 293–99 (1938).—Recent literature on the subject is reviewed with respect to silver, lead, copper, nickel, cast iron, steel and special alloys, both ferrous and nonferrous. The loss, when subjected to the action of $N/5$ HCl is for cast iron 259.2, steel (mild) 271.2, lead 17.0, tin 6.0, and nickel 3.0 g./sq. m./day. E.P.

**Respirator to prevent silicosis.** AMERICAN OPTICAL CO. *Mining Jour.* [Phoenix], **22** [2] 48 (1938); *Metal Cleaning & Finishing*, **10** [6] 447 (1938).—The features of this respirator which, if worn faithfully, will prevent silicosis are compactness, light weight, unobstructed vision, improved valves which facilitate inhalation and exhalation, and a more effective filter area (42 sq. in.). Facial adjustment is unnecessary, and it is easy to keep the apparatus in efficient working order. Illustrated. E.J.V.+P.G.H.

**Size reduction by impact.** JOHN T. FOWLER. *Chem. & Met. Eng.*, **45** [5] 230 (1938).—In the swing-hammer mill, the feed falls into the path of rapidly revolving hammers and passes over a screen bar or perforated-plate cage where that sufficiently reduced passes through; the remainder is returned for further grinding. Fineness of the grind is determined largely by the intensity of the blow which can be regulated by the speed of the rotor. Although material having a silica content above 30% is usually too abrasive to make economical grinding possible, larger bar openings will decrease the wear on the hammer sufficiently to allow for the economical grinding of flint, cullet, sand rock, etc. Removal from the feed of material already of desired size and uniform and continuous feed are necessary to obtain maximum efficiency. Wet grinding of materials usually produces much greater wear on hammers than dry grinding of the same materials. B.C.R.

**Thermal expansion and effects of heat treatments on the growth, density, and structure of heat-resisting alloys.** PETER HIDNERT. *Jour. Research Nat. Bur. Standards*, **20** [6] 809–24 (1938); R.P. 1106. Price 10¢.—Coefficients of linear expansion for various temperature ranges between 20° and 1000°C were obtained on an iron-chromium-aluminum alloy and three iron-chromium-aluminum-cobalt alloys. No polymorphic transition was observed between 20° and 1000°C. The alloys exhibited growth (0.82 to 2.81%). Densities increased 1.12 to 2.50% and tremendous grain growth occurred as a result of various heat treatments to 1400°C. R.A.H.

**Unique wheelbarrow.** ANON. *Can. Mining Jour.*, **59** [6] 316 (1938).—The body of the wheelbarrow is one half of an oil drum cut by a blowtorch along its length, with one end cut out. The body is mounted at an angle in scrap pipe sections so that it is horizontal when the workman stands erect. G.M.H.

**Viscosimeter suitable for materials of high viscosity.** A. A. CLARK AND H. J. HODSMAN. *Jour. Soc. Chem. Ind.* [London], **56**, 67–70 (Feb., 1937).—A rotational viscosimeter used over a range of 50 to $10^8$ poises is described. Diagrams of the apparatus and results obtained are given. G.R.S.

**Viscosity determination of slag systems.** J. R. RAIT AND R. HAY. *Jour. Roy. Tech. Coll.* [Glasgow], **4** [Part 2], 252–75 (1938).—An apparatus suitable for determining viscosities of fused silicates is described. Graphical results are given for the binary system lime–silica and the ternary system lime–silica–alumina for a range of temperatures. The concentric cylinder method of measuring viscosity was used, and methods of calibrating the apparatus built on this principle are described in detail. In a study of blast-furnace slags, the position of the liquidus was indicated by a marked rise in viscosity. With no alumina, the viscosity falls steadily with increase in lime without showing any deviation at either the composition of the disilicate or that of the eutectic. The most fluid slag of this system contains calcium disilicate and calcium sesquisilicate which has a viscosity of 1.8 poises at 1550°C. In the ternary system $CaO$–$Al_2O_3$–$SiO_2$, anorthite, gehlenite, and $SiO_2$ have the greatest influence in raising the viscosity at a particular temperature, while the presence of the sesquisilicate with Ca disilicate produces the most fluid slags. Illustrated. W.H.B.

**Viscosity and plasticity of disperse systems: XI, Comparison of three methods of determining the plastic-viscous properties of peat masses.** N. N. KULAKOFF. *Kolloid-Z.*, **80** [2] 204–12 (1937).—K. investigated the flow resistance of aqueous peat suspensions with capillary and rotating viscometers and by determining the speed of motion of hollow spheres in the suspensions. The three methods gave entirely different values. No explanation of this discrepancy can as yet be made. For Parts VI–VII see *Ceram. Abs.*, **16** [4] 137 (1937). F.P.P.

**X-ray microanalyzer.** L. v. HAMOS. *Jour. Sci. Instruments*, **15** [3] 87–94 (1938).—X-ray photomicrographs illustrate the application of the method to the solution of problems in mineralogy and metallography. 7 diagrams, 10 photomicrographs. J.L.G.

### BULLETIN

**Cemented carbide tools engineering bulletin TA-371.** CARBOLOY CO. Reviewed in *Mill & Factory*, **20** [2] 154 (1937). D.A.B.

### PATENTS

**Apparatus for electrically measuring grain-size range.** A. E. O'DELL (Haardt & Co., Akt.-Ges.). Brit. 487,232, June 29, 1938 (Dec. 14, 1936).

**Ball and pebble mill.** P. O. ABBÉ (Paul O. Abbé, Inc.). U. S. 2,122,399, July 5, 1938 (Jan. 11, 1934).

**Brickmaking machines.** J. B. HEWITT. Brit. 487,344, June 29, 1938 (Dec. 19, 1936).

**Electric furnace.** R. R. RIDGWAY AND B. L. BAILEY (Norton Co.). U. S. 2,121,744, June 21, 1938 (Oct. 20, 1933; Sept. 30, 1935). An electric furnace comprises a casing, a graphite resistor tube extending longitudinally

within the casing and opening to the outside thereof, a graphite sleeve removably and slidably fitted within the central portion of the tube and supported throughout its length thereby, the sleeve being in both heat and electrically conductive relationship with the tube and arranged to be charged *in situ* with the substance to be heated, means including electric terminals and removable closures for the ends of the tube which form a circuit of high conductivity that localizes the electrically developed heat to the central portion of the resistor, heat insulation between the resistor and the casing, and means for cooling the casing.

**Machine for decorating surfaces by stencil method.** L. D. SOUBIER (Owens-Illinois Glass Co.). U. S. 2,121,491, June 21, 1938 (Feb. 14, 1934).

**Method and apparatus for spraying powder, etc.** P. G. MARR. U. S. 2,123,537, July 12, 1938 (May 29, 1936).

**Regulator for controlling melting temperatures.** ALEXANDER WACKER GES. FÜR ELEKTROCHEMISCHE INDUSTRIE, G.M.B.H. Ger. 655,015, Oct. 25, 1935; Cl. 40*c*. 16.01; *Chem.-Ztg.*, **61** [103–104] 1019 (1937). D.A.B.

**Rotary filter.** A. J. BARNEBL (Swenson Evaporator Co.). U. S. 2,120,455, June 14, 1938 (Sept. 24, 1934).

**Treatment of mineral slurry as cement slurry, etc.** MIKAEL VOGEL-JØRGENSEN. Ger. 658,014, March 3, 1938 (Aug. 8, 1936); VI/80*b*. 3.14. A method for the treatment (conveying, drying, and calcining) of mineral slurry for the manufacture of cement, calcined lime, etc., is considered. The slurry is partially or completely transformed into froth or foam and in this state it is further treated. D.A.B.

**Viscosimeter.** G. F. HOFFMANN (Pittsburgh Plate Glass Co.). U. S. 2,122,470, July 5, 1938 (July 30, 1936).

## Kilns, Furnaces, Fuels, and Combustion

**Coal and its suitability for glass-furnace heating.** D. SISMEY. *Jour. Soc. Glass Tech.*, **21** [84] 215–34 (1937).—S. gives the most desirable properties of coals for use in gas producers as shown by nineteen coals from seven localities. Dull, hard, noncaking coals of low moisture, ash, and volatile matter contents are preferred, the fusion point of the ash in a reducing atmosphere being about 1300°. G.R.S.

**Distribution and properties of British coals.** J. G. KING. *Jour. Soc. Glass Tech.*, **21** [84] 198–213 (1937).—2 figures. G.R.S.

**Heat losses from furnaces and heating installations in intermittent operation. Calculation of nonstationary heat flow.** C. L. BEUKEN. *Feuerungstechnik*, **26**, 7–9 (1938).—In the heat insulation of periodic furnaces and heating plants, an important problem is the calculation of the minimum wall thickness necessary to maintain adequate insulation and reduce the heat losses by radiation and conduction to a minimum. An exact calculation of such heat flow is extremely complicated and is impossible in the majority of practical cases. The analogy between electrical and thermal conduction permits approximate calculations if the different parts of the heating plant are regarded as heat resistors or condensers of known resistance and capacity. E.P.

**Influence of moisture on the results of combustion calculations.** W. GUMZ. *Feuerungstechnik*, **26**, 9–10 (1938).—Errors varying from 0.95 to 1.81%, according to the type of coal used in the producer or gas employed for combustion, occur if the moisture in the air used for combustion is neglected. E.P.

**Relation between Stefan's radiation law, Nernst's heat theorem, and Maxwell's formula for the radiation pressure.** EUGENE GUTH AND ARTHUR E. HAAS. *Proc. Nat. Acad. Sci.*, **24** [5] 224–27 (1938).—The mathematical relationships are briefly discussed. J.L.G.

**Special atmospheres for industrial furnaces.** W. A. DARRAH. *Ind. Heating*, **4** [1] 26–30, 38; [2] 106–10 (1937).—The necessity of using special atmospheres is explained. Manufacturing special atmospheres from city gas, natural gas, charcoal, coke, fuel oil, or ammonia is described. Curves show the effect of H and water-vapor on pure Fe and of mixed gases on steel. Equilibria curves for gases at different temperatures are given, and types of furnaces for controlling atmospheres are described. M.H.

**Spectroscopic thermodynamics.** H. ZEISE. *Feuerungstechnik*, **26**, 1–6 (1938).—Z. discusses gaseous combustion and dissociation mathematically. E.P.

### PATENTS

**Electric heating of articles or material in a tunnel kiln.** C. W. THOMAS. Brit. 486,465, June 15, 1938 (Feb. 10, 1937).

**Means for heating furnaces.** ELECTRIC FURNACE CO. Brit. 485,654, June 9, 1938 (Oct. 26, 1935).

**Producer-gas plants and controlling the composition of producer gas.** J. A. MACDONALD. Brit. 485,655, June 9, 1938 (Oct. 22, 1936).

**Tunnel ovens.** GIBBONS BROS., LTD., AND E. W. EDWARDS. Brit. 486,628, June 22, 1938 (June 4, 1937).

## Geology

**Action of hydrochloric acid upon varying soil conditions.** F. K. HARTMANN AND F. O. W. MEYER. *Bodenkunde & Pflanzenernähr.*, **3**, 267–84 (1937).—The authors show how the current interest in soil analysis by means of concentrated HCl treatments, both hot and cold, has come about. An entire series of studies records the ingredients of soils from many localities, ascertained by standardized treatment with HCl in solubility tests. A research method has been devised to estimate soil ingredients in the gross for several layers or strata of soils; a demand has also arisen for accurate ascertaining of the properties and components of soils only partially known before but suspected of being valuable. The authors review the literature on the evolution of methods and results, beginning with the Americans Loughridge and Hilgard, whose experiments (also those of certain Dutch investigators) convinced them that up to a certain point soils were usually soluble in HCl but there would be an insoluble residue. Hissink, a German, contended that the use of concentrated HCl would establish a limit value corresponding to the individual peculiarity of a given soil. Such discussions went further than the natural limits of soil solubility, or otherwise, in HCl concentrates from a purely chemical point of view, but they ceased after other Germans concluded that there was no limit to soil solubility under suitable HCl treatment. Research carried out at the Institute of Vegetation and Forestry (Hannover-Münden) demonstrates the limits and efficiency value of the HCl-concentrate methods in testing soils. The results are shown in 5 tables. The influence of temperature upon total soil solubility in given localities and upon the solution of $Al_2O_3$ and $SiO_2$ and the solubility of $SiO_2$ and $Al_2O_3$ in a given soil quantity after 60 minutes are discussed. A test scale of values for HCl solubilities for 10 substances ranging from CaO 96.9 and MnO 76.3 to $SiO_2$ 19.6 and $K_2O$ 18 is given. Results are reported for soils treated with hot and cold HCl concentrates; the milder the treatment at room temperatures, the smaller is the mass going into solution. Whether the HCl is applied hot or cold, it is impossible to prevent its action on $SiO_2$ coverings. The duration of applying the cold HCl concentrate had only a subordinate influence on the result. If, in 55 min., ma-

terials going into solution showed quantitative increase, such increase was limited to $Fe_2O_3$, $Al_2O_3$, and $SiO_2$. 22 references. K.R.

**Adsorption phenomena in relation to soil stabilization.** H. F. WINTERKORN. *Proc. Highway Research Board*, **15**, 343–55 (1935).—Data are given on the surface character of soil material formed under varied conditions of weathering and on the possible change of this character by exchange adsorption (base exchange) and other surface reactions (soaps). The importance of these reactions for soil stabilization is shown. H.M.R.

**Bauxite clays of Grudków as a chemical raw material.** K. GLASER. *Przemysl Chem.*, **22** [1] 1–2 (1938).—Bauxite clays from Grudków are mentioned as raw material for the production of aluminum compounds such as $Al_2(SO_4)_3$, $Al(CH_3COO)_3$, $KAl(SO_4)_2$, and especially $AlCl_3$. The importance of subsequently conducting research in the direction of Wasilewski, Kaczorowski, and Dynkin for creating an aluminum industry in Poland which is independent of countries abroad is stressed. The Hiller-Müller method, which is considerably cheaper than the noted Bayer method, is recommended for the production of $Al(OH)_3$. D.A.B.

**Cartography in the refractories industry.** J. W. BRADLEY. *Refrac. Jour.*, **14** [3] 127 (1938).—In the mining of fire clay and ganister, geology maps give valuable assistance in determining the location of faults, either known or suspected. B. discusses applications of this knowledge, especially pertaining to proper drainage and to complications in mining that may result from the various types of "faults." B.C.R.

**Cathodo-luminescence of calcium silicate.** EI-ICHI IWASE AND SATOYASU IIMORI. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **34**, 173–77 (1937–38) (in English).—Yellow cathodo-luminescence of wollastonite and pectolite is ascribed to the presence of a small amount of manganese. J.B.A.

**Cathodo-luminescence spectra of feldspars and other alkali aluminosilicate minerals.** SATOYASU IIMORI AND JUN YOSHIMURA. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **31**, 281–95 (1937) (in English).—The spectrum of the mineral under bombardment with cathode rays was analyzed. Feldspar from four localities in Japan and specimens of jadeite, leucite, kunzite, and lepidolite were examined. In every case three bands were found with crests at 660 to 640, 590 to 540, and 470 to 400 mμ. These agree fairly well with bands in the fluorescence spectra of sodium and potassium. The relative intensity of the bands depends upon the impurities present. When feldspar contains a relatively large amount of calcium or manganese the cathodo-luminescence is intense. J.B.A.

**Ceramic resources of Tennessee.** GEORGE I. WHITLATCH. *Bull. Amer. Ceram. Soc.*, **17** [7] 289–91 (1938).

**Characteristics of sepiolite from Ampanandrava. Formula of sepiolite.** H. LONGCHAMBON. *Bull. Soc. Franç. Mineral.*, **60**, 232–76 (1937).—On the basis of dehydration, X-ray, and chemical study, L. proposes that any sepiolite can be represented by either $Si_4O_{11}(Mg\cdot H_2)_3\cdot H_2O(H_2O)_4$ or $(Si_4O_{11})_3Mg_3H_2\cdot 3H_2O(H_2O)_4$. These formulas represent well the triple rôle of water in its constitution as well as the gross chemical composition. There are three stages of dehydration, and sepiolite transforms after dehydration to a pyroxene with fibers oriented as in the original mineral. See *Ceram. Abs.*, **16** [1] 41 (1937). H.I.

**Clay.** A. B. SEARLE. *Nature*, **141** [3570] 583–85 (1938).—S. reviews the development of present knowledge of the structure of clays. He summarizes from Bragg: "In both complex silicates and clays, the atoms (represented as spheres at the apices of tetrahedra) form a pattern of rectangular cells or units, and the various sheets or layers must fit perfectly in combination even if they differ slightly in separate existence." According to Bragg, clays fall in two groups: (1) those allied to halloysite, kaolinite, nacrite, and dickite, and (2) those allied to pyrophyllite, including montmorillonite, beidellite, bentonite, and fuller's earth. The suggested structures explain the colloidal properties of clay particles. Recent work by Bradley, Grim, and Clark ("Behavior—," *Ceram. Abs.*, **17** [8] 288 (1938)) shows the existence of a set of hydrates in which the *c* axis increases regularly with introduction of water molecules into the unit cell. The looseness of these water molecules gives easy movement to the clay particles but prevents loss of shape of the mass. Bragg believes this introduction of sheets of water molecules which increase the *c* axis while the *a* and *b* axes remain constant is "the cause of plasticity." S. states that Bragg's clay structures at last allow clear and simple explanations of clay properties. J.L.G.

**Clays of Alabama.** T. N. MCVAY. *Bull. Amer. Ceram. Soc.*, **17** [7] 287–89 (1938).

**Decade of research on the nature of clay.** PAUL F. KERR. *Jour. Amer. Ceram. Soc.*, **21** [8] 267–86 (1938).

**Geology of glacial sand and gravel deposits.** D. G. RUNNER. *Roads & Streets*, **79** [5] 43–47 (1936).—R. describes types of glaciers, types and topography of glacial deposits, and the character of material in each deposit. The fundamental geology of glacial deposits is reviewed. P.G.H.

**Harmotome.** J. SEKANINA AND J. WYART. *Bull. Soc. Franç. Mineral.*, **60**, 139–45 (1937).—A chemical and X-ray study of the monoclinic zeolite, harmotome, shows it to have the composition $Ba_2Al_4Si_{12}O_{32}\cdot 12H_2O$. Unit cel lparameters are $a = 9.80$, $b = 14.10$, $c = 8.66$Å with $d_{100} = 8.05$Å, $d_{010} = 7.05$Å, $d_{001} = 7.11$Å, and $\beta = 55°$ 10′. Axial ratios are 0.695 : 1 : 0.614. H.I.

**Magnesian silicates of asbestiform or lamellar habit not belonging to the antigorite group.** S. CAILLERE. *Bull. Soc. Franç. Mineral.*, **59**, 353–73 (1936).—X-ray powder patterns, dehydration curves, and chemical analyses of a number of asbestiform minerals belonging to the sepiolite and palygorskite groups are given. One fibrous mineral tested has the properties of a fibrous kaolinite. H.I.

**Magnesium-zinc spinels from Ceylon.** B. W. ANDERSON AND C. J. PAYNE. *Mineralog. Mag.*, **24** [158] 547–54 (1937).—Spinels from Ceylon which contain large amounts (15%) of ZnO and small amounts (0.5%) of FeO are described. A plot of densities *vs.* refraction shows that such "gahno spinels" are higher in density for the same refractive index than pleonast (FeO) spinels. H.I.

**Minerals of serpentine.** S. CAILLERE. *Bull. Soc. Franç. Mineral.*, **59**, 163–316 (1936).—Specific characteristics of the essential minerals of serpentine were studied by optical, chemical, thermal, and X-ray methods. The chemical composition of the minerals corresponds to $H_4Mg_3Si_2O_9$ with sometimes a small amount of Al replacing Si + Mg. Two types of antigorite are distinguished: α antigorite, characterized by an endothermic reaction during loss of water at 650°C and an exothermic reaction at 750°, and β antigorite, showing only the endothermic reaction at 650°C. α antigorite, after dehydration at 650°, produces an amorphous substance which recrystallizes at the exothermic reaction to a mixture of enstatite and olivine. During the heating of β antigorite, there is no amorphous phase, and the material recrystallizes progressively during the dehydration. H.I.

**Natural resources of zirconium.** A. ESME. *Ind. Chim.*, **25** [292] 300 (1938). R.W.D.

**Nature of potash fixation in soils.** GARTH W. VOLK. *Soil Sci.*, **45** [4] 263–76 (1938).—V. studied the fixing capacity of kaolinite, white bentonite, and the zeolites (artificial) muscovite and sericite, both before and after treatments with carbonated water and dilute sodium carbonate solutions, and of albite and orthoclase, both before and after treatment with dilute sodium bicarbonate solution. The influence on fixation of adding colloidal silica and alumina to kaolinite, pyrophyllite, soils, and soil colloids and of grinding kaolinite, sericite, and muscovite for four days in a ball mill was also studied. The fixing power of soils was determined after leaching with 0.0001 *N* $H_3PO_4$ and after treating with monocalcium phosphate. The influence on fixation of removing colloidal silica and alumina from soils, bentonite, and a freshly decomposed granite, by means of dilute solutions of sodium carbonate and hydrochloric acid, was also studied. The results showed that samples of untreated minerals did not fix appreciable

amounts of potash, although one sample of muscovite fixed 1700 p.p.m. of $K_2O$, and bentonite fixed 8850 p.p.m. Potash-fixing capacities of muscovite and sericite were appreciably increased by treatment with carbonated water but were not significantly changed by treatment with sodium carbonate solution. Additions of colloidal silica and alumina did not change the amount of potash fixed by kaolinite but greatly increased the amount fixed by pyrophyllite. The grinding of kaolinite, sericite, and muscovite for four days in a ball mill did not change the capacity of these materials to fix potash. Treatment of a soil and of decomposed granite with sodium carbonate solution increased the capacity of these materials to fix potash, and treatment of these materials and of a bentonite with weak hydrochloric acid decreased this capacity. As greater amounts of colloidal alumina were extracted, the capacity to fix potash decreased, and as decreasing amounts of colloidal silica with a constant amount of colloidal alumina were removed, the capacity to fix potash decreased. None of the pure minerals had a fixing power approaching that of clays, and the results do not warrant ascribing the fixing power to any definite mineral. It is significant that the removal of free alumina from clays decreases fixing power, and that on replacement of this alumina the fixing power is also restored. There is considerable evidence that the products formed by $Na_2CO_3$ treatment and the clay minerals decomposed by HCl are associated with potash fixation. G.R.S.

**Observations on boehmite.** M. S. Goldsztaub. *Bull. Soc. Franç. Mineral.*, **59**, 348–50 (1936).—The complete analogy of the powder pattern of boehmite ($Al_2O_3 \cdot H_2O$) to that of lepidocrocite ($Fe_2O_3 \cdot H_2O$) has offered a method of deducing the parameters of boehmite by comparison with the known parameters of lepidocrocite. Those found for boehmite by this method are $a$ = 3.78 Å, $b$ = 11.8 Å, $c$ = 2.85 Å. H.I.

**Paragenesis of cookeite and hydromuscovite associated with gold at Ogofar, Caramarthenshire.** A. Brammall and J. G. C. Leech. *Mineralog. Mag.*, **24** [157] 507–19 (1937).—Specimens of cookeite were analyzed chemically, optically, and structurally. The composition assigned is $LiAl_4Si_3AlO_{10}(OH)_8$ with alternating muscovite-like layers, $[Al_2Si_2AlO_{10}(OH)_2]$, and gibbsite-like layers, $[LiAl_2(OH)_6]$. Cookeite is regarded as a distinct species, more closely related to the chlorite group than to the micas, talc, or the clay group. The indices of refraction are $\alpha$ = 1.575, $\beta$ = 1.580, $\gamma$ = 1.595 with $2E$ = 80°. The hydromuscovite analyzed is similar to muscovite but departs from the generalized muscovite formula, $(OH)_8K_4Al_8(Si_{12}Al_4)O_{40}$, by (1) a high proportion of hydroxyl groups, (2) a low total of atoms in place of standard $K_4$, and (3) a low total atom assemblage corresponding to the standard $Al_8$. Both cookeite and hydromuscovite are considered products of a low-temperature hydrothermal phase of mineralization. H.I.

**Particle size groups of crude clay and base-exchange phenomena of HCl extracts of soils.** F. K. Hartmann and F. O. W. Meyer. *Bodenkunde & Pflanzenernähr.*, **3**, 284–308 (1937).—The authors investigated particle content (particles less than 2$\mu$) in HCl soil extracts, HCl soluble bases and their exchanges, fractional colloids and particle value, and basal possibilities of insoluble residues. A review of pertinent literature is given. Generally speaking, soil study has demonstrated that a relation exists between the sum of soluble materials (ascertained by treating soils with hot HCl concentrates) and the colloid content of soils, to the extent that colloid-rich soils yield a high total value in HCl extracts; in colloid-poor sands, consequently, slight masses of HCl soluble materials were found. These phenomena have been confirmed by the authors. In the study of diluvial rocks such as sands and clays, *e.g.*, different particle groups appear, and only insignificant masses of HCl soluble materials are found therein. Results of research carried out on 18 soils from widely different localities are extensively and clearly tabulated in 2-page and 4-page analyses; the percentage of particle groups less than 2$\mu$ in relation to the total of soluble substances is expressed as a quotient in two cases. Each table is explained and discussed in detail. The study of particle-size groups of HCl insoluble residues, following hot treatment of the soils involved, showed that the chief component originates in acid-soluble materials of fractional clays and is less than 2$\mu$. Nevertheless, the crude fraction through the acid extract claimed only half; the residue remained insoluble. Besides the particles less than 2$\mu$, groups of particles of more than 2$\mu$ were supplied in the acid soil extracts. It is believed that the property of solubility in hot HCl is not characteristic of the particle average but is much more dependent on the nature of existing mineral components, which is of primary significance for solubility or nonsolubility. The grade of dispersion must be regarded as secondary in importance. Treatments with concentrated HCl, according to the soil being analyzed, cause 3 to 12 times as many bases to go into solution as there are insoluble bases left, or 6 times as many on the average of soils. Rise in the crude clay content relative to the acid extracts is summarized in formulas and elucidated in the text and tables. Masses constructed by replacement of different minerals were analyzed by mineralogical methods for individual mineral components and to estimate whether they were weathered or unweathered in their more or less dispersed condition. Soils under 2 mm. studied for acid solubility or nonsolubility, for base exchange conditions, and for particle size and type were traced back to their individual mineral representatives. 14 references. K.R.

**Properties of clay.** F. H. Clews, H. H. Macey, and G. R. Rigby. *Chem. & Ind.*, **57** [10] 221–27 (1938).—The discussion includes (*a*) clay minerals, (*b*) drying of clay, (*c*) plasticity, (*d*) colloidal nature of clay and the action of heat on clays, (*e*) thermal decomposition of kaolin, (*f*) effect of heat on fire clays and building clays, and (*g*) changes in texture. G.R.S.

**Rock formation: nature's chemical industry.** G. W. Morey. *Chem. & Ind.*, **57** [18] 428–29 (1938).—All of the chemical processes by which the varieties of rocks and minerals have been produced in nature are prototypes of present-day methods and processes used by the chemical engineer in industrial separation of minerals and ores. G.R.S.

**Sericite in banket.** G. H. Stanley. *Jour. Chem. Met. Mining Soc. S. Africa*, **38**, 188–89 (1937).—S. describes an occurrence of sericite in banket. A.H.E.

**South Australian rutile.** Anon. *Mining Rev. S. Australia*, **66**, 78 (1937); abstracted in *Bull. Imperial Inst.*, **36** [1] 78 (1938).—A deposit of rutile in the hundred of Para Wirra 4 miles southeast of Williamstown and another in the hundred of Borossa are described. The rutile content of the rock is low, rendering erection of concentration tables uneconomic. A.P.S.

**Stilbite.** J. Sekanina and J. Wyart. *Bull. Soc. Franç. Mineral.*, **59**, 377–83 (1936).—Chemical and X-ray studies show the composition of stilbite to be $NaCa_2Al_5Si_{13}O_{36} \cdot 14H_2O$. The unit cell parameters are $a$ = 13.60Å, $b$ = 18.13Å, $c$ = 11.29Å with $d_{100}$ = 5.36Å, $d_{001}$ = 8.92Å, and $\beta$ = 52° 0′. The axial ratios are $a:b:c$ = 0.750:1:0.623. Although stilbite is monoclinic in symmetry, it approaches orthorhombic. Similarities with heulandite are noted. H.I.

**Strong fireproof films made from bentonite clay.** Anon. *Science News Letter*, **33** [25] 400–401 (1938).—Colloidal particles of bentonite are spread out into a film; when put under pressure they turn transparent and are very strong yet flexible. The films take printing and their electrical resistance makes them comparable to mica. P.G.H.

**Tantalite deposits of southwestern Uganda.** Anon. *Bull. Imperial Inst.*, **35** [2] 180–84 (1937).—The occurrence and development are described. A.P.S.

**Titration curves and dissociation constants of soil acidoids.** A. N. Puri and A. G. Asghar. *Soil Sci.*, **45** [5] 359–67 (1938).—Titration curves of soil acidoids closely resemble those of weak dibasic acids. The point of inflection occurs approximately 4 $p_H$ units above the initial $p_H$ of the acidoid and corresponds to the neutralization of the first hydrogen. Dissociation constants of soil acidoids

can be determined from their titration curves. The $p_K$ values of soils are fundamental constants, referring to the dissociation of the first hydrogen atom and indicating the activity of soil acidoids. The smaller the $p_K$ value, the stronger is the acidoid. The titration curves of weak acids having dissociation constants of less than $10^{-4}$ with strong alkalis such as NaOH are defined by the usual mass law equation, $p_H = p_K + \log$ salt/acid; hence when the acid is half neutralized, *i.e.*, the ratio salt/acid is unity, $p_H = p_K$. Thus the $p_H$ value of a weak acid when it is half neutralized with NaOH is equal to the log of the reciprocal of its dissociation constant, or $p_K$. Just as $p_H$ is used for comparing the intensity of acidity of different solutions, $p_K$ values could be used for comparing the activity of the acids, so that the higher the value of $p_K$, the weaker is the acid. G.R.S.

**Weathering of rocks.** D. G. RUNNER. *Roads & Streets*, **79** [10] 39–42 (1936).—R. describes in detail the various mechanical and chemical agencies of weathering and their effect on rocks. The effect of weathering on the physics and chemistry of road materials is discussed, especially with regard to the life of the finished road. P.G.H.

**Wolframite and scheelite in Southern Rhodesia.** ANON. *Bull. Imperial Inst.*, **35** [3] 372 (1937).—Mines are approaching the production stage. A.P.S.

BOOK AND PREPRINTS

**Chromite.** ROBERT H. RIDGWAY. Preprint from U. S. Bur. Mines Minerals Yearbook, 1938. 9 pp. Govt. Printing Office, Washington, D. C. Price 5¢. R.A.H.

**Feldspar.** ROBERT W. METCALF. Preprint from U. S. Bur. Mines Minerals Yearbook, 1938. 10 pp. Govt. Printing Office, Washington, D. C. Price 5¢. R.A.H.

**Fluorspar and cryolite.** H. W. DAVIS. Preprint from U. S. Bur. Mines Minerals Yearbook, 1938. 16 pp. Govt. Printing Office, Washington, D. C. Price 5¢. R.A.H.

**Magnesite and other magnesium compounds.** PAUL M. TYLER AND A. E. DAVIS. Preprint from U. S. Bur. Mines Minerals Yearbook, 1938. 10 pp. Govt. Printing Office, Washington, D. C. Price 5¢. R.A.H.

**Ore-Testing Studies, 1936–1937. Special Methods of Analysis and Testing and Details of Tests on Various Ores. Metallurgical Division Progress Report No. 22.** STAFF OF THE ORE-TESTING SECTION. *U. S. Bur. Mines Repts. Investigations*, No. 3370, 174 pp. Free. The second annual report discusses the progress made in investigations relating to standardization of testing methods, the making of routine tests for other Government agencies, and the establishment of satisfactory methods of treating representative ores from various mining districts. R.A.H.

PATENT

**Production of beryllium.** OSIAS KRUH. U. S. 2,121,084, June 21, 1938 (Aug. 29, 1935). In the manufacture of beryllium or beryllium alloys, the process comprises reducing beryllium oxide with the aid of carbonaceous material in the presence of a protective gas which is inert to beryllium at a temperature sufficient to vaporize into the gas the beryllium formed by reduction.

## Chemistry and Physics

**Analysis of open-hearth slags.** A. P. DUBINSKIĬ, L. S. ZAIKIN, AND V. D. PONOMAREV. *Zavodskaya Lab.*, **7**, 93–94 (1938).—The method is based on (1) determination of chrome and manganese from one sample by oxidation of $Cr_2O_3$ to $CrO_3$ by chloric acid and titration of $CrO_3$ by ferrous sulfate with a subsequent determination of Mn according to Lang and Kurtz; (2) separation of $Fe_2O_3$, $Al_2O_3$, $Cr_2O_3$, and $P_2O_5$ by pyridine and determination of CaO and MgO in the filtrate after a preliminary separation of Mn with bromine (without determination of Mn); (3) determination of iron and Mn after separating the filtrate from $SiO_2$; (4) determination of $P_2O_5$ after dissolving the ignited and weighed sum of sesquioxides; and (5) determination of $Al_2O_3$ by the difference. P.B. & E.S.

**Capillary systems: XIX-a, Systematics of porous systems.** E. MANEGOLD. *Kolloid-Z.*, **80** [3] 253–65 (1937).—M. classifies the various porous systems according to (1) voids, capillaries, and pressure systems, (2) ordered, unordered, disperse, and coherent, and (3) the degree and type of integration. All classifications are additionally subdivided. Several practical examples of the application of this classification system to porous system scientific problems are given. **XIX-b, Calculated and experimentally determined pore volume in compact and coherent materials.** *Ibid.*, **81** [1] 19–35 (1937).—In a given material, if $S$ = the volume fraction of solid matter, $W$ = the volume fraction of pores, and $V$ = the specific volume requirement, then $W = 1 - S$ and $V = 1/S$. Methods for determining $S$ by means of X-rays, refractive index, density, and Van der Waals' equation are given. The molecular volume of dissolved substances is 30 to 33% greater than $S$ in the molecular volume of solid matter in the case of alkali halides. Methods for determining the capillary volume in coherent substances by determining the volume of aggregates and by determining the capillary volume volumetrically and gravimetrically are described. The values of capillary volume in wood, leather, gels, zeolites, ceramics, carbons, meals, and powders are discussed. **XIX-c, Effective pore volume in branching canal systems.** E. MANEGOLD AND K. SOLF. *Ibid.*, pp. 36–40.—Using Elford and Ferry's method, the effective pore volume in branching and integrated canal systems is calculated, and formulas are established for pore volumes in canal systems with three additional types of networks. **XIX-d, Permeability to liquids and gases of canal, skeleton, and network capillary systems.** E. MANEGOLD. *Ibid.*, [2] 164–79.—M. considers various types of fluid flow through different capillary systems. Concepts of permeability evolved for characterizing the systems covered are based on simple flow laws and give formulas made up of experimentally determinable terms. The definitions of gas permeability as given in the literature are reviewed, and units of measurement for permeability, laminar flow through capillaries, and gas flow at ordinary pressures through very narrow capillaries are given. **XIX-e.** *Ibid.*, [3] 269–94.—Permeability to gases of cellulose membranes, cellulose ester membranes, leather, silica gel, sandstone, concrete, etc., is a characteristic value that depends on the internal geometry of the capillary system. F.P.P.

**Cone deformation study of the barium oxide–clay–silica system.** WARREN A. ZIMMER AND ARTHUR S. WATTS. *Bull. Amer. Ceram. Soc.*, **17** [7] 291–92 (1938).

**Crystal structure of sodium metaborate, $Na_2(B_2O_4)$.** SSŬ-MIEN FANG. *Z. Krist.*, **99**, 1–8 (1938).—The results of structure determinations by the Laue and rotating crystal methods differ widely from those found by Cole, Scholes, and Amberg (*Jour. Amer. Ceram. Soc.*, **18** [2] 58 (1935); **20** [6] 215 (1937)) with the powder diffraction method. The unit cell of sodium metaborate is rhombohedral with $R = 7.22$Å and $\alpha = 111° 29'$; the density is 2.464 and there are six molecules of $NaBO_2$ per unit cell. The space group is $D^6_{3d} - R\bar{3}c$. All atoms are in layers normal to the 3-fold axis, 3.23Å apart. See *ibid.*, p. 214. H.I.

**Determination of aluminium by titration with alkali.** A. E. MARTIN. *Jour. Soc. Chem. Ind.* [London], **56**, 179–80 (June, 1937).—The arrangement for electrometric titration is illustrated. The method is described, and directions for using indicators are given. G.R.S.

**Determination of magnesium oxide in limestone quickly and accurately.** A. V. VINOGRADOV. *Zavodskaya Lab.*, **7**, 179–81 (1938).—A modified Kolthoff method consists in (1) preliminarily isolating magnesium by alkalis, permitting the use of large samples, (2) isolation of sesquiox-

ides by calcium carbonate, (3) precipitation of magnesium by barium hydroxide, and (4) titration of the excess acid, not of the alkaline liquid. Any amount of magnesium can be determined in calcium compounds with an accuracy of 1 to 3% (with a small magnesium content) and of 0.2 to 0.4% (with a magnesium content up to 10%). The time required is 2 to 3 hr., excluding the time for the isolation of silica. P.B. & E.S.

**Determination of minute quantities of lead.** P. G. JACKSON. *Jour. Soc. Chem. Ind.* [London], **56,** 211–13 (June, 1937).—The experiments are of three classes: (1) those in which the solution was acidified with 2 ml. of 33% acetic acid, (2) those containing 2 ml. of gelatin-acetic acid (0.5% gelatin in 33% acid), and (3) those in ammoniacal solutions. The effects of various reagents are discussed. The colorimetric determination of lead as sulfide is described. G.R.S.

**Determining ferrous iron in soil solutions and a study of the effect of light on the reduction of iron by citrate and 2:2′-dipyridyl.** VLADIMIR IGNATIEFF. *Jour. Soc. Chem. Ind.* [London], **56,** 407–10 (Oct., 1937).—A method for determining ferrous iron in soils and soil solutions by the use of 2:2′-dipyridyl is outlined. The value of $AlCl_3$ as a decolorizing and precipitating reagent for soil solutions is shown. Experimental evidence demonstrates the stabilizing action of $AlCl_3$ on ferrous iron. A study was made of the effect of light on the reduction of iron by citrate, glucose, and 2:2′-dipyridyl. The blue end of the spectrum is responsible for the acceleration of the reduction of iron. G.R.S.

**Dipotassium sodium cobaltinitrite and its application to the gravimetric determination of cobalt.** C. F. CUMBERS AND J. B. M. COPPOCK. *Jour. Soc. Chem. Ind.* [London], **56,** 405–407 (Oct., 1937).—The extent of hydration and conditions of formation of dipotassium sodium cobaltinitrite were studied. G.R.S.

**Heat of formation and specific heat of aluminum carbide.** SHUN-ICHI SATOH. *Sci. Papers Inst. Phys. Chem. Research* [Tokyo], **34,** 50–59 (1937–38) (in English).—The mean specific heat of $Al_4C_3$ between 0° and 305°C is given by $C = 0.2282 + 2.12 \times 10^{-4}\, t° - 2.842 \times 10^{-8}\, (t°)^2$. The heat of the reaction $4Al + 3C = Al_4C_3$ is +63,200 cal. J.B.A.

**Heat of hydration and the exothermal transformation for inyoite. Several conceptions of the borate transformation.** N. S. KURNAKOV, A. V. NIKOLAEV, AND A. G. CHELISHCHEVA. *Compt. Rend. Acad. Sci. U.R.S.S.,* **16,** 92–94 (1937). P.B. & E.S.

**Heating curves of borates.** N. S. KURNAKOV, A. V. NIKOLAEV, AND A. G. CHELISHCHEVA. *Compt. Rend. Acad. Sci. U.R.S.S.,* **16,** 87–90 (1937).—Borates were heated at a rate of 2.5°/ min., *i.e.*, to about 900° in 6 hr. The curves obtained had four types of breaking points: (1) endothermal, connected with the separation of water; (2) endothermal, connected with polymorphism (boracite), reversible; (3) endothermal, evidently connected with fusion (potassium borite), reversible; and (4) exothermal, connected with transformation of solid matter, irreversible. *Calcium borates.* Inyoite had four breaking points with absorption of heat; it can easily be distinguished from pandermite (2 points) and colemanite (1 point). The latter has a relatively small thermal effect of the exothermal transformation. The characteristic small breaking points of pandermite distinguish it sharply from other calcium minerals. *Magnesium borates.* For boracite, the reversible endothermal breaking point lies at about 350° (polymorphism), and the absence of an exothermal transformation is characteristic. The latter was also missing for ascharite, whose highly situated endothermal breaking point (about 650°) is connected with the separation of constitutional water. Pinnoite possesses two exothermal and an irreversible endothermal transformation at about 325°. *Double borates.* Potassium borite has a reversible endothermal breaking point. It lies after the exothermal transformation, taking place at a lower temperature. Hydroboracite is characterized by two exothermal breaking points, borosodiumcalcite (containing much water), and by the low temperature of its endothermal breaking point. The heating curves of borates are so individual that they can be used for the determination of minerals. P.B. & E.S.

**Measurement of the proportions of calcite and aragonite in precipitated chalk.** M. L. SMITH. *Jour. Soc. Chem. Ind.* [London], **56,** 283–87 (Aug., 1937).—Quantitative comparison of the X-ray diagram provides the most accurate measure of the ratio of calcite and aragonite in precipitated chalks. When the required apparatus is not available, the determination of specific gravity offers a measure which is almost as accurate, providing proper precautions are taken. The procedure is somewhat tedious. For routine purposes where limited accuracy is sufficient, a rough quantitative method using the Meigen (cobalt salt) color test is satisfactory. Microscopic examination is valuable, but the interpretation requires great care. If flocculation could be overcome, a flotation method would be quick and accurate. G.R.S.

**Mechanism of adsorption of electrolytes by aluminium hydroxide sols.** Z. YA. BERESTNEVA AND V. A. KARGIN. *Zhur. Fiz. Khim.,* **10,** 593–600 (1937).—When introducing sodium sulfate into $Al_2O_3$ sol, the activity of $Al_2O_3H^+$ cations decreases considerably. It can be concluded, therefore, that equilibrium concentrations of potential-determining ions change abruptly during the coagulation process. Equilibrium concentrations of aluminium chloroxide cations in a diluted sol are lower than in the ultrafiltrate. P.B. & E.S.

**Mortar for unit masonry.** Y. R. ANDERSON. *Jour. Can. Ceram. Soc.,* **7,** 39–46 (1938).—The data presented constitute a progress report of investigations on the problem of designing mortars that would be adapted to building units of various physical characteristics. Data on the absorption rates of typical brick, ranging from semivitrified stiff-mud brick to porous dry-pressed brick, are given. A suggested method of preparing mortar is included. J.G.P.

**Potentiometric determination of silica in silicate rocks.** V. M. TARAYAN. *Zavodskaya Lab.,* **7,** 176–79 (1938).—Potentiometric titration by the Schucht and Möller method gives a curve corresponding to the curve of titration of a feeble acid by concentrated alkalis. If barium nitrate is added, a curve is obtained corresponding to titration of a concentrated acid by a concentrated alkali, making it possible to determine silica with a sufficient accuracy in the presence of any amount of aluminium oxide. P.B. & E.S.

**Purification of gases by I. G. Alkazid process and extraction of sulfur by I. G. Claus process.** H. BÄHR. *Chem. Fabrik,* **11,** 283–93 (1938).—B. gives details of the extraction of $CO_2$ and $H_2S$ from gases. Particularly efficient processes are obtained by the use of aqueous solutions of alkaline salts of phenols and their derivatives, known as Alkazid Solutions M, Dik, and S. M and Dik solutions consist of a mixture of aminocarboxylic acid salts, the S solution being alkaline phenolates or their derivatives. Ammonia can also be extracted by these solutions. Details are given of the selective behavior of the Alkazid solutions, the effect of temperature and regeneration of the solutions, their application to industrial processes, and their uses as absorbing reagents as in the production of ammonium sulfide by the absorption of ammonia gas in the gasification of coal. The I. G. Claus process for the extraction of sulfur consists in burning the $H_2S$ extracted by the Alkazid process in air to produce sulfur. In the improved process, the $H_2S$ is burned only to $SO_2$ which then reacts with further $H_2S$ to give the element S. E.P.

**Quantitative determination of cobalt by o-hydroxyquinoline.** S. L. TSINBERG. *Zavodskaya Lab.,* **6,** 1009 (1937). P.B. & E.S.

**Quantitative separation of manganese and magnesium by o-hydroxyquinoline.** S. L. TSINBERG. *Zavodskaya Lab.,* **6,** 1007–1008 (1937).—The addition of hydroxylamine or $SO_2$ recommended by R. Berg (*Ceram. Abs.,* **15** [7] 222 (1936)) in the precipitation of manganese is superfluous. Manganese is quantitatively precipitated by oxine not only in a neutral solution but also in a feebly

ammoniacal or a feebly acetic acid medium. The latter fact makes possible a quantitative separation of Mn and Mg, because the latter forms no precipitate even in a very feeble acetic acid medium. P.B. & E.S.

**Quantitative spectrochemical analysis with the microphotometer.** F. Twyman, G. F. Lothian, and E. S. Dreblow. *Jour. Soc. Chem. Ind.* [London], **57** [3] 75–79 (1938).—All methods of spectrochemical analysis involve some form of spectrograph or spectrometer which is used to detect the presence of certain lines in the spectrum being examined and thus to determine the presence of certain elements in the specimen. One of several pieces of apparatus may be used in conjunction with the spectrograph to determine the relative intensities of a pair of spectral lines of a minor element and the major element in order to determine quantitatively the proportion of the minor element in the specimen. G.R.S.

**Specific weight and hardness of natural borates and products resulting from their heating.** N. S. Kurnakov, A. V. Nikolaev, and A. G. Chelishcheva. *Compt. Rend. Acad. Sci. U.R.S.S.*, **16**, 90–92 (1937). P.B. & E.S.

**Structure of cryolite, $Na_3AlF_6$.** St. v. Náray-Szabo and K. Sasvári. *Z. Krist.*, **99**, 27–31 (1938).—Determinations by the oscillating crystal method show cryolite to be monoclinic with the cell dimensions, $a$ = 5.46Å, $b$ = 5.61Å, $c$ = 7.80Å, $\beta$ = 90° 11′. The space group is $C_{2h}^5 - P2_1/n$, $z = 2$. The structure is composed of $AlF_6$ octahedra and Na ions. H.I.

**Surface tensions of molten mixtures with a cryolite base.** E. Elchardus. *Compt. Rend.*, **206** [20] 1460–62 (1938).—The surface tensions of cryolite with $Al_2O_3$ in different ratios were experimentally determined at a temperature 20°C above the melting point. Addition of $AlF_3$ reduces the surface tension; NaF increases it, while $Al_2O_3$ has no clearly defined effect. Below the melting point, cryolite has the formula $AlF_6Na_3$; in the molten state, it presents a mixture of $AlF_3$ and NaF. An unstable form of cryolite has been found with a melting point 8° lower than that of the stable form; the formula is very likely $(AlF_6Na_3)_2$. M.H.

**Ternary system $FeO$–$Al_2O_3$–$SiO_2$.** R. Hay, James White, and Thomas H. Coulfield. *Jour. Soc. Glass Tech.*, **21** [85] 270–80 (1937).—The diagram for the system $FeO$–$Al_2O_3$–$SiO_2$ has been constructed from thermal and microscopic data. The molybdenum wire-wound furnace and the technique employed for determining the thermal curves are described. Four ternary combinations occur: (1) ferrous oxide, spinel, fayalite; (2) fayalite, spinel, mullite; (3) fayalite, silica, mullite; and (4) alumina, spinel, mullite. Three ternary eutectic points occur: (*a*) 62% FeO, 3% $Al_2O_3$, 35% $SiO_2$, with a melting point of 980°; (*b*) 68% FeO, 3% $Al_2O_3$, 29% $SiO_2$, with a melting point of 1002°; and (*c*) 72% FeO, 3% $Al_2O_3$, 25% $SiO_2$, with a melting point of 1080°. All three are characterized by a narrow, deep trough which runs behind the very infusible $SiO_2$-rich region of the $FeO$–$SiO_2$ system, indicating that a small amount of $Al_2O_3$ (about 5%) in the presence of FeO is effective in fluxing $SiO_2$. 7 figures. G.R.S.

**X-ray examinations of tricalcium silicate.** W. Jander and J. Wuhrer. *Zement*, **27** [6] 73–76; [7] 86–88 (1938).—Two abnormal kinds of crystals have been determined. The first is lower in lime as given in the formula; the other is a mix crystal containing some $3CaO \cdot Al_2O_3$. Distorted and stressed crystals show a lesser resistance to agressive solutions. This is an explanation of dead burning. The two-component system $CaO$–$SiO_2$ of Ferguson and Merwin, corrected by Greig, should be amended because of solubility (CaO in $2CaO \cdot SiO_2$ and $2CaO \cdot SiO_2$ in $3CaO \cdot SiO_2$). The mix crystal formation ($3CaO \cdot SiO_2$ and $3CaO \cdot Al_2O_3$) must be inserted in the ternary system $CaO$–$Al_2O_3$–$SiO_2$. New experiments are necessary. F.E.V.

BOOKS

**Analytical Chemistry of Tantalum and Niobium.** W. R. Schoeller. Chapman & Hall, Ltd., London, 1937. xvi + 198 pp. Price 21s. See *Ceram. Abs.*, **16** [6] 188 (1937). A.P.Som

**Colloid Systems.** A. von Buzagh. Translated by Otto B. Darbishire and edited by William Clayton. Reinhold Publishing Corp., New York. 311 pp. Price $9. Reviewed in *Science News Letter*, **33** [22] 356 (1938).—This is a comprehensive and completely indexed volume on the nature of colloidal chemistry. See *Ceram. Abs.*, **15** [8] 260 (1936). P.G.H.

PATENTS

**Barium and calcium sulfate production.** Jean McCallum (National Lead Co.). Can. 374,234, June 7, 1938 (Feb. 28, 1936). G.M.H.

**Manufacture of manganese dioxide.** A. F. S. Bellone (Soc. des Usines Chimiques Rhône-Poulenc). U. S. 2,122,735, July 5, 1938 (Jan. 10, 1935). A process for the preparation of artificial oxide of manganese containing a large proportion of manganese dioxide consists in oxidizing manganous hydroxide in an aqueous ammoniacal solution by means of one of that group of substances including oxygen in a pure state and oxygen diluted with an inert gas under such a pressure that the partial pressure of the oxygen is greater than 0.30 kg./sq. cm.

**Obtaining compounds of beryllium, magnesium, etc., practically free of iron.** Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler. Ger. 654,839, Nov. 9, 1933; 12*m*. 4; *Chem.-Ztg.*, **61** [103–104] 1018 (1937). D.A.B.

**Preparation of titanium oxygen compounds.** Paul Weise and Friedrich Raspe (Titanges. m.b.H.). U. S. 2,121,215, June 21, 1938 (April 12, 1937). In a method for the preparation of hydrous titanium oxides by thermal hydrolysis from a titanium sulfate solution, the step consists in continually adding water to a titanium sulfate solution undergoing hydrolysis in an amount and at a rate of addition sufficient to maintain at substantially constant value the acid concentration free and combined with titanium of the hydrolyzing solution, the value being substantially that of the solution just prior to hydrolysis.

**Production of ceramic coloring matters.** Deutsche Gold- und Silber-Scheideanstalt vorm. Roessler. Brit. 487,078, June 29, 1938 (March 2, 1936).

**Synthetic spinels.** Ekbert Lederle and Rudolf Brill (I. G. Farbenind. A.-G.). U. S. 2,122,180, June 28, 1938 (July 28, 1937). The process of producing synthetic spinels according to the known process of Verneuil by fusing mixtures of zinc oxide and titanium dioxide comprises preheating mixtures which contain the oxides in a molecular ratio of 0.9 to 2ZnO : $1TiO_2$ to temperatures between 500° and 1000°C before fusing the mixtures.

## General

**Ceramic education and employment.** R. J. Montgomery. *Jour. Can. Ceram. Soc.*, **7**, 4–5 (1938).—Since the establishment of the Ceramic Department at the University of Toronto in 1925, the course has been designed primarily for the heavy clay products industry. It was recently broadened to include all the nonmetallic minerals except fuels. The curriculum was revised to include both the ceramic and chemical use of nonmetallic minerals. M. requests the coöperation of industry by (1) encouraging young men to enter the field, (2) giving students summer employment in plants, and (3) employing graduates trained for the industry. J.G.P.

**Chemical examination of dusts causing silicosis.** H. V. A. Briscoe. *Chem. & Ind.*, **57** [9] 208–209 (1938).—Types of collectors for taking dust samples are (1) filters composed of volatile solids, (2) filters composed of soluble (not in water) substances, and (3) purely mechanical separators. Freshly formed dusts are the most dangerous,

particularly those from flint. The solubility of a dust is an important factor. Silica solubility can be minimized by additions of charcoal, lime, magnesia, or aluminum powder to the dust. See "Characteristic—," *Ceram. Abs.*, **17** [2] 88 (1938). G.R.S.

**Control of industrial dust.** THEODORE HATCH. *Amer. Jour. Pub. Health*, **27** [7] 671 (1937).—H. discusses dust control, considering the following aspects: measurement of dust concentration using the impinger method, evaluation of the dust control program in terms of permissible dust concentration, and development of basic methods of design of exhaust systems. See "Exhaust—," *Ceram. Abs.*, **15** [11] 340 (1936); "Dust—," *ibid.*, **16** [8] 262 (1937); "Industrial—," *ibid.*, **17** [4] 166 (1938). B.C.R.

**Definite place in manufacturing taken by research.** H. B. SPEAKMAN. *Can. Machinery*, **48**, 85–86 (June, 1937).—S. outlines the work and purpose of the Ontario Research Foundation and cites examples showing the need of such foundations. Reference is made to undeveloped resources, especially rich clay deposits in the Province of Ontario that find limited use because of their composition and properties. D.A.B.

**Discussion of papers on industrial dusts.** A. BRAMMALL, H. V. A. BRISCOE, G. W. GRAY, L. MIDDLETON, J. KING, F. HAYNES, AND W. R. JONES. *Jour. Chem. Met. Mining Soc. S. Africa*, **38**, 81–97, 116–19, 145–47 (1937).—The following papers are discussed: (1) Sampling of industrial dusts by means of the "labyrinth" (*Ceram. Abs.*, **17** [2] 89 (1938)); (2) Characteristic properties of certain industrial dusts (*ibid.*, p. 88); (3) Instrument designed to record continuously the amount of dust in air, by C. W. Biccard Jeppe and E. C. Halliday; (4) Geochemistry applied to the problems of silicosis (*ibid.*); (5) Hydrolysis of rock-forming minerals (*ibid.*). **Authors' reply to discussion.** *Bull. Inst. Mining & Met.*, No. 398, pp. 31–35 (1937); *Jour. Chem. Met. Mining Soc. S. Africa*, **38**, 227–29 (1937). A.H.E.

**Historical notations on Polish nomenclature: clay to aluminum.** K. SARNECKI. *Przemysl Chem.*, **21** [12] 350–51 (1937).—S. discusses the etymology of Polish words relating to clays and aluminum. D.A.B.

**How budget research?** T. W. HOWARD. *Chem. & Met. Eng.*, **45** [2] 78 (1938).—Information contributed by 25 corporations on the budgetary and accounting procedures used for their organized research programs is summarized. In determining the amount to be expended for research, 11 companies base their budgets on the expected value obtained from their research, while 3 others relate their budgets to the volume of sales. In most cases, the cost of research projects, whether successful or unsuccessful, are charged against operating costs. B.C.R.

**Protecting health of wage earners repays industry.** J. A. FAULKNER. *Can. Machinery*, **48**, 83–84, 134 (June, 1937).—The health of the wage earner is considered from the humanitarian as well as the economic viewpoint. The doctor should be consulted whenever a new building is planned or a change in process or routine is to be brought about. A survey shows that 50% of workers have ailments, 14% serious; they lose 7 days' work a year (4 times the loss through industrial accidents). Tuberculosis (resulting often from exposure to dust containing free silica), cancer, and industrial diseases (silicosis) and poisonings are the prevalent disorders among workers. D.A.B.

**Willard D. Richardson.** ANON. *Bull. Amer. Ceram. Soc.*, **17** [7] 292–94 (1938).

**Silicosis in the pottery industry.** J. F. BROMLEY. *Brit. Jour. Radiol.*, **11** [126] 345–53 (1938).—The harmful agent in the materials used is the uncombined (free) silicon dioxide dust in the form of flint; the dusts vary in their free silica content and in the size of the silica particles. The smaller the particles, the greater is the danger; 70% of the harmful particles are less than 1 micron in diameter, *i.e.*, smaller than many pathologic bacteria. Silica, though insoluble in water, is soluble in alkalis and alkaline body fluids. Finely divided silica may act as a soluble protoplasmic poison, particularly to endothelial cells. This could be highly important in one stage of earthenware production where alkali is added to the body preliminary to casting. B. outlines inhalation of dust as the primary factor in causing silicosis, with its respiratory results. He considers English pottery work in two broad divisions, china and earthenware, and lists the constituent materials explaining the different risks as follows:

| Earthenware body | | China body | |
|---|---|---|---|
| 3 ball clay, | = 1/4 | 2 kaolin | = 2/3 |
| 3 china clay | = 1/4 | 1 Cornish stone | = 1/3 |
| 4 free flint, | = 1/3 | 2 bone ash | = 2/3 |
| 2 stone | = 1/6 | | |

The composition and qualities of kaolin (the china clay of the St. Austell district of Cornwall), Cornish stone, and bone ash are explained in detail, with the suggestion that some of these silica combinations may play a part of their own in the production of clinical silicosis or in modifying the radiological picture of the typical "free silica risk." Wet grinding of these constituents into an essentially safe wet pan condition is distinguished from the pulverizing or dry-crushing method; powdered flint dust prepared for use as bedding material by the latter method constitutes a serious silicosis risk. The resulting slip offers further silicosis hazard. The dry earthenware body presents a special source of danger, its dried scraps giving rise to a dust composed of about one-third free flint. This explains unexpected cases of silicosis, occurring without reasonable cause among workers in the slip or plastic stages or those dealing with the ware after the first firing and dipping, such as glost placers. The dust involved is a mixed one, likely to modify the classical X-ray picture. The risk from the earthenware body dust is increased more extensively than necessary by the scraps of biscuit ware found all over the benches, walls, floors, and drying ovens. Becoming dried and pulverized by ordinary routine operations, the dust contains a considerable proportion of very fine free flint, originating from the body of the ware itself. The Staffordshire potter is unwilling to use methods preventing shrinking (one result of firing) which do not involve the use of free flint; the public, also, would not be satisfied with flint-free sanitary ware. (The term "sanitary earthenware" does not include, in this usage, sanitary fire clay and flint-free "cane-and-white.") After 20 years the caster shows unmistakable signs of silicosis. The pottery industry as a whole comprises about 60 separate occupations, in 30 of which the worker is exposed to free silica dust, either as pure flint or as a mixed dust. B. tabulates these occupations accompanied by silicosis as follows: (1) millers and mill laborers, with 6 subdivisions, the mill laborer being subjected to all the flint dusts of all of these subdivided occupations; (2) slip makers, who prepare the body for earthenware, including sanitary ware, china and fire clay, fire clay and earthenware (mixed), and marl; (3) workers in the potters' shop; (4) mold makers, with 10 subdivisions, and (5) various laborers whose duties bring them into dust contacts from the dried earthenware body or the biscuit placing warehouse (shop sweepers, cleaners, etc.) Numerous risks are eliminated by improved exhaust ventilation and by more rigorous supervision of the uses of flint. Biscuit ware prepared for firing still has two serious and important silicosis risks in connection with the saggers and the bedding in finely ground powder; china is bedded in pure flint and earthenware in a fine sand. The china bedder and flinter and the flint miller, who prepares the flint for bedding by pulverizing or dry crushing, present the most serious silica risks in the industry. Death has occurred in 3 years after work in a dry crushing mill; the signs are marked in all china biscuit placers after 15 years. As polishers increased during the recent depression, the risks also increased; "seconds" among the glost ware were worked up by polishing instead of being discarded. The polishing was done on a sandstone wheel for coarse flaws and on a silicon carbide wheel for fine ones. B. discusses the dangers in tile manufacture. If an efficient substitute for bedding flint were discovered, the silicosis risk would be almost entirely banished from the china potters' shop. 6 illustrations. 5 references. K.R.

**Silicosis in pottery workers.** R. A. KEMP HARPER.

*Brit. Jour. Radiol.*, **11** [126] 354–65 (1938).—The clinical and industrial factors producing silicosis are discussed. From the 1932 survey of the industry, workers employed for 20 years were found to have silicosis in the following proportions: general earthenware workers 35, sanitary ware workers 38, earthenware tile workers 38, china workers 31, and flint millmen 18.5%. Thus, at the end of 20 years' exposure, one third of the pottery workers of all branches had acquired the disease. Important factors are (1) silica intensities in the dust, (2) continuance of the worker's exposure, (3) cleanliness in the work, and (4) precautions taken by employers. In modern factory buildings efficient design has greatly reduced the dust content of the air; the use of alumina instead of flint has reduced the disease incidence. Research is being directed toward the discard of dangerous materials in the bedding processes, *e.g.*, earthenware ingredients or the tile body. Physique of workers is important in disease resistance; certain physical types are undesirable for work in any quarter or process. Fitness for work is also stressed; preliminary stages of tuberculosis are revealed in the examination before hiring an employe, and this disease, often easily superimposed in silicosis, constitutes a menace. In South Africa, where silicosis first became an important menace among the goldworkers, two main silicosis types are recognized: (*a*) simple, noninfective, and (*b*) infective, due to any organism. H. discusses their radiological distinctions and characteristics. He remarks that "the pottery worker in general tends to acquire a soft type of silicosis, with less nodulation than stone masons in South Africa, but many exceptions also occur." Twelve cases are explained, and the radiological reproductions for each are given. There is no one silicosis type for a given occupation; men employed in the same kind of work for the same length of time may show entirely different radiographic records of the disease inroads. The previous occurrence of weakening respiratory diseases, such as acute bronchitis, influenza, and pneumonia, causes the lung parenchyma to succumb to the inhalation of silicosis-producing dust. 10 references. K.R.

**Solubility of silica dusts.** E. J. King. *Nature*, **140** [3538] 320 (1937).—K. states that many of the values reported ("Mineralogical—," *Ceram. Abs.*, **16** [7] 226 (1937)) for the solubility of finely powdered silicates are too high because the method used does not eliminate completely the fine particles in suspension. The table gives K.'s values for the rate at which silicic acid will pass into solution from a powdered mineral of a certain range of particle size when suspended at a given concentration in a liquid.

$SiO_2$ (mg.) dissolved by 100 cc. of liquid
(1) 0.1 g. of dust in 100 cc. of 1% sodium bicarbonate solution

| Days at 37° | Quartz 20–40μ | Quartz < 1–5μ | Plates < 1–2.5μ | Fibers 1–10μ long 0.1–1μ wide |
|---|---|---|---|---|
| 1 | 0.71 | 0.76 | 0.32 | 0.51 |
| 3 | 0.97 | 1.65 | 0.39 | 0.57 |
| 5 | 1.02 | 2.08 | 0.32 | 0.62 |
| 8 | 1.20 | 2.74 | 0.46 | 0.78 |
| Hours at 100° | | | | |
| 2 | 1.25 | 2.05 | 0.30 | 0.37 |
| 4 | 1.46 | 4.15 | 0.40 | 0.39 |
| 6 | 2.02 | 4.37 | 0.42 | 0.39 |

(2) 2 g. dust in 100 cc. acetic fluid at 37°

| Days | Precipitated silica | Quartz | Kaolin | Mica |
|---|---|---|---|---|
| 4 | 7.04 | 4.53 | 0.22 | |
| 8 | 7.12 | 5.91 | 0.26 | 1.0 |
| 16 | | 5.82 | 0.24 | 1.8 |

J.L.G.

**Trend of research in plastic materials.** Gilbert Morgan. *Chem. & Ind.*, **57** [1] 3–11(1938).—An outline, with tables, shows the rapid increase in the production of plastics. Transparent methacrylate polymerides as substitutes for glass are discussed. Their new applications include the production of optical lenses for cameras, telescopes, and opera glasses, where their high transparency to ultra-violet rays is an advantage. The application of new methods of investigation, such as X-ray analysis or studies of electrical or electron diffraction properties, is discussed. The future of research in plastics is briefly treated. G.R.S.

**W. E. S. Turner, Fellow of the Royal Society.** Anon. *Bull. Amer. Ceram. Soc.*, **17** [7] 305–14 (1938).

BOOKS

**Ceramic Data Book.** 10th ed. Industrial Publications, Inc., Chicago, 1938. 292 pp. Outstanding features of this enlarged and improved edition are (1) a complete and up-to-date directory of all important sources of supply for equipment and materials; (2) a catalogue section giving purchasing information on the products of 104 companies selling to the ceramic industries, indexed and arranged for easy reference; and (3) concise reviews of the literature on the ceramic industry from Sept., 1936, to Sept., 1937. The data section has been brought up to date with additions of valuable charts and tables, so that it now contains a wealth of accurate operating data of value to ceramic manufacturers.

**Graphic Routes to Greater Profits.** John W. Esterline. Esterline-Angus Co., Indianapolis. 350 pp. Price $3.00. Reviewed in *Mining Jour.* [Phoenix], **22** [2] 43 (1938).—E. describes the application of the scientific method to the conduct of industry. He discloses the modern technique of critical examination and diagnosis of industrial operations. Executives and engineers will find this volume of value. Illustrated. P.G.H.

**Principles of Chemical Engineering.** William H. Walker, Warren K. Lewis, William H. McAdams, and Edwin R. Gilliland. McGraw-Hill Book Co., Inc., New York, 1937. 3rd ed. revised and rewritten. xi + 749 pp. Reviewed in *Nature*, **141** [3567] 459–60 (1938).—The most extensive changes are in the chapters on the flow of fluids, the flow of heat, and diffusional processes. J.L.G.

**Report of the Building Research Board for 1936.** Department of Scientific and Industrial Research. H. M. Stationery Office, London, 1937. 210 pp. Price 4s net. H.E.S.

**Symposium on Silicosis.** B. E. Kuechle. Employers Mutual Liability Insurance Co., 1937. 266 pp. Price $3.00. Reviewed in *Amer. Jour. Pub. Health*, **28** [6] 788 (1938). B.C.R.

**Weight lifting by industrial workers.** Anon. *Home Office Safety Pamphlet*, No. 16, 44 pp. (1937). H. M. Stationery Office, London. Price 45¢. Procurable through the British Library of Information, 270 Madison Ave., New York, N. Y. The relation of weight lifting to accidents is discussed. A brief bibliography is included. B.C.R.

PATENTS

**Ceramic.** Mitchell Carter (E. B. Carter) and Gustav Heinz. U. S. 2,121,018, June 21, 1938 (July 18, 1936). A process of making ceramic articles comprises mixing ceramic materials with latex in quantity sufficient to serve as a temporary binder therefor prior to firing, forming articles from the mix, and firing the articles to burn out the latex.

**Device for the determination of powder and dust particle sizes and for the determination of dust content.** W. Barth. Ger. 660,107, June 30, 1933; *42l.* 13.04; *Chem.-Ztg.*, **62** [35] 311 (1938). D.A.B.

**Roofing granule and method of coloring.** H. R. Gundlach (Central Commercial Co.). U. S. 2,123,419, July 12, 1938 (Oct. 3, 1935). A method of coloring granules of mineral matter selected from the group consisting of slate, quartz, shale, and traprock for use on composition roofing comprises attaching color pigment to the surface of the granules with a thin layer of weatherproof cement comprising the reaction product of phosphoric acid with a compound of one of the common metals of Groups III, IV, VII, and VIII of the Periodic Classification of the Elements which is capable of forming a sesquioxide, heating the mass between 400° and 800°F, and simultaneously agitating the mass to prevent agglomeration.

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Kolloid-Z.
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Pub. Nat. Bur. Econ. Research, Inc.
Razvedka Nedr
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Reichsarb.-Bl.
Reports of the Imperial Fuel Research Institute, Japan
Reports of the Imperial Industrial Research Institute, Osaka, Japan
Researches Electrotech. Lab. [Tokyo]
Rev. Optique
Ricerca Scientifica
Russko-Germanskiĭ Vestnik Nauki i Tekhniki
Schweizer Brauerei Rundschau
Scientific Journal of the Royal College of Science
Sitzungberichte der Akademie der Wissenschaften in Wien, Mathematische-Naturwissenschaftliche Klasse
Soap
Stemag-Zeitung
Studio [London]
Technische Blätter
Technisches Gemeindeblatt
Tech. Studies Field Fine Arts
Teknisk Ukeblad
Tennessee State Div. Geol. Bull.
Times Literary Supplement
Trans. Inst. Chemical Engineers (London)
Trans. State Institute of Applied Chemistry [U.S.S.R.]
Trudy Ivanovskogo Khimiko-Technologicheskogo Inst.
Trudy Vsesoyuznogo Mendeleevskogo S'ezda
United States Department of Agriculture Publications
University of North Carolina, Eng. Expt. Sta. Bull.
Verhandel. Akad. Wetenschappen Amsterdam, Afdeel Natuurkunde
Wärme
Wärme- und Kälte-Technik
Zeitschrift für Metallkunde
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